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CONTENTS

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TRENDS IN BLACK BASS FISHING TOURNAMENTS IN CALIFORNIA, 1985-1989

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Reports from California black bass fishing tournaments during the period 1985-1989 were analyzed to provide estimates of and trends in Statewide annual effort, catch, and fish mortalities. A total of 824 tournaments was conducted from which 649 reports were returned by sponsors. The number of permits issued each year increased from 57 in 1985 to 234 in 1988, then decreased to 226 permits in 1989. Over the 5-year study period, an estimated 816,558 hours of fishing effort representing 85,813 angler-days were expended in these tournaments to catch 158,954 bass. Annual estimates of Statewide catch per hour in the tournaments ranged from 0.172 in 1986 to 0.228 in 1987. Total initial mortality was estimated to be 2,981 fish over the 5-year period and was highest during spring months. Initial mortality rates were significantly reduced following implementation of special handling and weigh-in procedures imposed by fishery managers to increase survival of released bass. Information collected to date does not suggest that additional restrictions on black bass tournament angling or changes in the permitting and reporting process are necessary to further protect the black bass fishery.

INTRODUCTION

Over the past 20 years, interest in black bass (*Micropterus* spp.) fishing and tournament fishing has increased significantly (Holbrook 1975, Schramm et al. 1991). Fishery managers have used data from bass fishing tournaments to estimate fish abundance and provide trend information on fishing success (Aggus and Rainwater 1975, Farman, Neilson and Norman 1982, Willis and Hartmann 1986).

Black bass tournaments first became popular in California in the early 1970's. Tournaments are sponsored by private organizations or businesses for profit, and by non-profit groups. These contests are designated as either team tournaments or draw tournaments. Team tournaments are conducted with two anglers fishing as a team from one boat. Their catch of bass (not exceeding the combined State daily bag limit for each individual) is weighed together, and teams compete against one another based on total weight of their catch. In draw tournaments, anglers draw for boat partners and all anglers compete individually. Although two anglers may fish from the same boat, their daily catches are usually weighed separately. In some multi-day draw tournaments the weight of the catch for both anglers is combined for each day, and partners are rotated each day of the contest.

During the period 1975-1989, under authority provided in the Fish and Game Code of California, sponsors of any fishing contest in California which offered prizes or other inducements exceeding $200.00 in total value were required to obtain a permit from the California Department of Fish and Game (CDFG). However, before 1986, individual prizes offered in team tournaments could not exceed $200.00. Consequently, permits were not issued nor reports submitted for team tournaments. In 1986, the restriction was eliminated and sponsors applied for and were issued permits for team tournaments offering higher prize values.

All permitted tournaments were "weigh-in" type contests in which the fish were brought daily by contestants to a central weigh-in site at a specified time. Competitors were required to comply with all State fishing regulations. The Statewide daily bag limit was five fish per angler and the minimum size limit was 305 mm total length (TL). State regulations prohibited the use of live bait in tournaments and boats participating in the tournament were required to have an operational aerated live well to keep the bass alive. Additional "Special Conditions" to improve the survival of released bass were appended to all permits beginning in 1988. "Special Conditions" included: bass transported between the boats and weigh-in site must be held in water-filled containers; a 3-min maximum time limit that bass could be held in the containers; a maximum of 5 fish per container and a requirement that any bass greater than 5 lbs (2.27 kg) be held in an individual container; the use of holdingtanks near the weigh-in site; a maximum allowable fishing time of 6 h between weigh-ins for tournaments conducted between 15 June and 15 September; and all black bass are to be returned to the water alive and in good condition.

Beginning in 1985, sponsors that were issued a permit were required to submit a report to the CDFG. This report included information on the date of the tournament, number of competitors, duration of the tournament, total catch, weight of the total catch, species and weight of the largest fish, and total number of fish released alive. Sponsors that did not return the required report were contacted in an attempt to retrieve the information. In some instances, sponsors were not reachable and information could not be obtained.

Initial mortality (fish dead at weigh-in) rates reported for tournament-caught bass vary greatly for individual tournaments and have been reported to range from 2 to 61% (Holbrook 1975, Chapman and Fish 1983). Schramm et al. (1985) reported initial and total mortality (initial mortality plus fish dying after release) rates in 18 Florida tournaments averaged 9% and 14%, respectively. Survival rates for angler-caught and released fish vary depending on a number of factors including spawning periods, water temperatures, depth at which bass are caught, and stress due to handling and confinement (Horton and Lee 1982, Feathers and Knable 1983, Gustaveson and Wydoski 1991). In spite of attempts to keep catches alive, some fish were dead when weighed-in at the conclusion of the contest.

Effort, catch and mortality estimates from black bass tournaments are useful in developing fisheries management plans and regulating tournament effort. Duttweiler (1985) reported that in 1983, 25% of the states surveyed collected some data from tournaments and Schramm et al. (1991) reported that 76% of the inland agencies

surveyed obtained some type of statistics from competitive fishing events. In most cases, reporting procedures relied on voluntary compliance (Willis and Hartmann 1986, Whitworth 1987).

In this paper, we analyze data from California black bass tournament reports to estimate annual angler effort, catch, and fish mortality, and examine trends in these variables in black bass tournament angling.

METHODS

We analyzed all permits issued and reports received for the calendar years 1985-1989. Canceled tournaments were deleted from the database. Information from the sponsor's reports was summarized by month to provide data on angler effort, catch, and initial fish mortality for each year. The percent of dead fish reported prior to 1988 was compared by Chi-square analysis to the percent during 1988-1989 to evaluate the effect of the "Special Conditions", mandated by the CDFG, on initial mortality rates in permitted black bass tournaments.

To account for permitted tournaments that did not return completed reports, total effort and catch were estimated by expanding the reported information by the total number of days of fishing effort indicated on the applications of those permittees that did not complete reports. Initial mortality was estimated by multiplying the monthly initial mortality percentage from the reported contests by the estimated monthly total catch.

RESULTS

The CDFG issued 824 permits during 1985-1989 for black bass tournaments (Appendix 1). Sponsors returned reports for 649 of these tournaments. Return rates ranged from 45.6% in 1985 to 93.6% in 1988. The greatest number of tournaments conducted in a single year occurred in 1988 when 234 permits were issued.

Sponsors reported 67,816 angler-days, 641,379 angler-hours of fishing effort, and 122,931 black bass weighed-in during the study period. The mean length of the angler day, based on reported duration of individual contests, ranged from 9.2 to 10.6 hours annually. Statewide annual catch per hour (CPH) ranged from a low of 0.172 in 1986 to a high of 0.228 in 1987. The estimated total effort over the 5-y period was 85,813 angler-days, during which 158,954 black bass were weighed-in (Appendix 2). The mean weight of bass was 0.74 kg, and increased annually from 0.63 kg in 1985 to 0.79 kg in 1989. Team tournaments comprised the majority of tournaments accounting for 67, 69, 74, 86, and 74% of the contests in 1985, 1986, 1987, 1988, and 1989, respectively.

Sponsors reported 2,271 dead bass at weigh-in. Based on annual initial mortality rates and estimated total black bass caught during tournaments, we estimated the total initial mortality over the 5 y to be 2,981 fish (Appendix 2).

Reported initial mortality was generally lowest during October and highest in June (Fig. 1). Significantly fewer ($X^2 = 89.2$, 95% C.I., 1 d.f.) bass were reported as dead

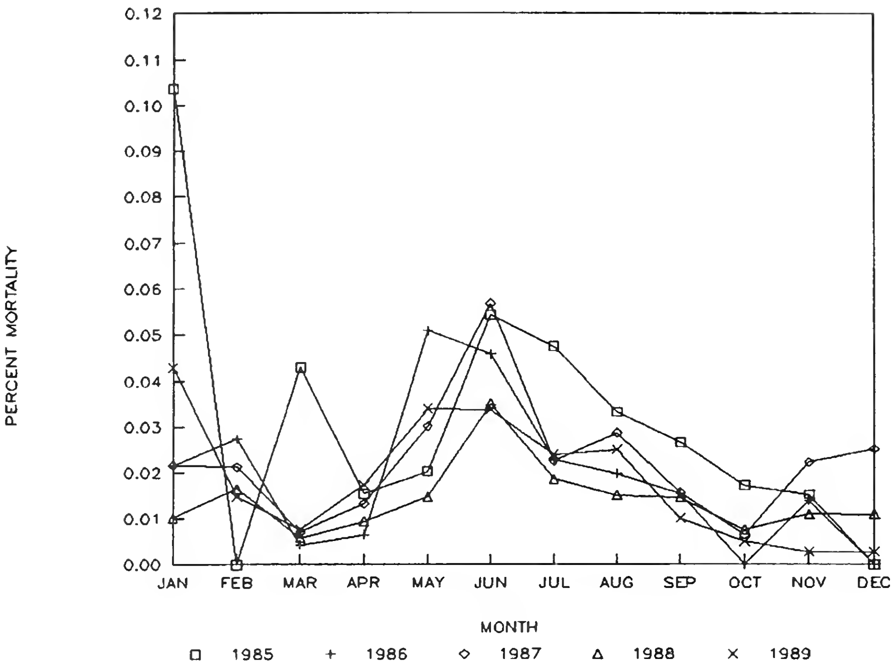

Figure 1. Monthly initial mortality of black bass from California tournaments, 1985-1989.

by sponsors following implementation of “Special Conditions” for black bass tournaments in 1988 (Fig. 2).

DISCUSSION

We observed a three-fold increase in the number of permits issued from 1985 to 1986. This increase was likely due to the regulation change that allowed sponsors to conduct team tournaments where individual prizes greater than $200.00 could be offered. The number of permits issued for draw tournaments also increased in 1986 as a result of the overall increased popularity of competitive bass fishing, although team tournaments remained the most numerous. The number of permits issued and total angler days peaked in 1988.

The estimated total catch of black bass tripled from 1985 to 1987 and remained fairly constant through 1989. We conclude that the increased catch was due to increased effort and did not reflect larger bass populations. Willis and Hartman (1986) reported CPH increased from approximately 0.1 to slightly more than 0.2, and the average size bass in the catch decreased from approximately 1.0 to 0.75 kg for Kansas bass club tournaments during an 8-y period. These trends were reported to be the result of better fishing for high numbers of small fish. Holbrook (1975) compared the catches of 46 national bass tournaments held from 1967 to 1974 in several southeastern

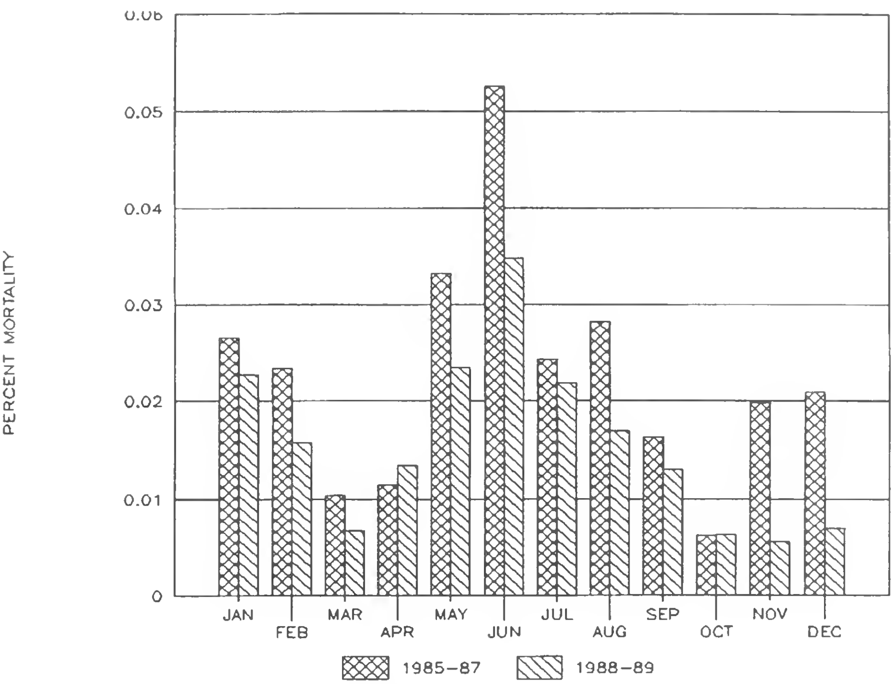

Figure 2. Comparison of monthly initial mortality of black bass from California black bass tournaments before and after imposition of "Special Conditions" in 1988.

states and the unweighted mean CPH for these contests was 0.31. The mean CPH for 1,203 Alabama bass club tournaments from 1986-1989 was 0.249 and the average size bass weigh-in was 0.72 kg (McHugh and Reeves 1990). Mean CPH estimated in this study was less than reported for southeastern waters, but comparable to Kansas tournaments. Mean CPH has not indicated any trends over the 5-y period and suggests the quality of fishing did not change. The mean weight of fish weighed-in during this study was comparable to weights reported in other studies. The annual increase in weight was most likely due to more tournaments fishing under self imposed 330-mm TL minimum length limits rather than changes in the fish population.

Annual initial mortality rates exceeded 2% prior to 1988 and declined in 1988 and 1989 after initiation by the CDFG of the "Special Conditions" for black bass tournament permits.

Highest initial mortality rates generally occurred during the late spring each year with the exception of very high rates reported for January and March 1985. These high rates were the result of high mortalities reported for one event conducted during January 1985 and for one of two tournaments conducted during March 1985. Elevated late-spring mortalities were probably the result of additional stress placed on post-spawn bass and concurrent high water temperatures. Lowest mortality rates were generally reported during October.

Total mortality in catch-and-release black bass tournaments has been reported to

be from 1.3 to 1.9 times greater than initial mortality (May 1973, Welborn and Barkley 1974, Archer and Loyacano 1975, Seidensticker 1975, and Schramm et al. 1985). Using a factor of 1.9, we estimated total mortality of black bass in catch-and-release permitted tournaments was about 5,664 fish during the 5 study years.

Studies at major California reservoirs indicate annual black bass harvest rates exceed 45% (Rawstron and Hashagen 1972, Rawstron and Reavis 1974, and Van Woert 1980). High harvest rate is a major detriment to maintaining quality black bass angling in California. Mortality of black bass resulting from tournaments in California is believed to be a small percentage of total angling mortality. While catch-and-release ethics promoted by tournament sponsors and anglers did not result in 100% survival of released fish, such practices do not appear to be a factor for maintaining satisfactory black bass fisheries. Tournament catch-and-release practices may, in fact, lead to peer pressure on recreational anglers to release fish and subsequently, to a reduction in Statewide harvest rates.

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LITERATURE CITED

Aggus, L.F., and W.C. Rainwater. 1975. Estimating largemouth bass population in reservoirs from catches in angling tournaments. Ann. Conf. Southeast. Assoc. Game and Fish Comm. Proc. 29:106-118.

Archer, D.L., and H.A. Loyacano, Jr. 1975. Initial and delayed mortalities of largemouth bass captured in the 1973 national Keowee B.A.S.S. tournament. Ann. Conf. Southeast. Assoc. Game and Fish Comm. Proc. 28:90-96.

Chapman, P., and W. Fish. 1983. Largemouth bass tournament catch results in Florida. Ann. Conf. Southeast. Assoc. Fish and Wild. Agencies Proc. 37:495-505.

Duttweiler, M. W. 1985. Status of competitive fishing in the United States: Trends and state fisheries policies. Fisheries (Bethesda) 10(5):5-7.

Farman, R.S., L.A. Neilson, and M.D. Norman. 1982. Estimating largemouth bass abundance using creel census and tournament data in the fishing-success method. N. Am. J Fish. Manage. 2:249-256.

Feathers, M., and A. Knable. 1983. Effects of depressurization upon largemouth bass. N. Am. J. Fish. Manage. 3:86-90.

Gustaveson, A. W., R.S. Wydoski. 1991. Physiological response of largemouth bass to angling stress. Am. Fish. Soc. Trans. 120:629-636.

Holbrook, J.A. II. 1975. Bass fishing tournaments. Pages 408-415 *in* H. Clepper, ed. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Horton, J., and D. Lee. 1982. Harvest and mortality of tournament caught and released largemouth bass at Don Pedro Reservoir, California. Calif. Dept. Fish and Game, Inland Fish. Admin. Rpt. 82-3.

May, B.E. 1973. Evaluation of large scale release programs with special reference to bass fishing tournaments. Ann. Conf. Southeast. Assoc. Game and Fish Comm. Proc. 26:325-329.

McHugh, J.J., and W.C. Reeves. 1990. Bait! Bass anglers information team. Page 22-23,34 *in* Alabama Conservation. May/June.

Rawstron, R.R. and K.A. Hashagen, Jr. 1972. Mortality and survival rates of tagged largemouth bass (*Micropterus salmoides*) at Merle Collins Reservoir. Calif. Fish and Game 58:221-230.

______, and R.A. Reavis. 1974. First-year harvest rates of largemouth bass at Folsom Lake and Lake Berryessa, California. Calif. Fish and Game 60:52-53.

Schramm, H. Jr., P. Haydt, and N. Bruno. 1985. Survival of tournament-caught largemouth bass in two Florida lakes. N. Am. J. of Fish. Manage. 5:606-611.

______, M.L. Armstrong, N.A. Funicelli, D.M. Green, D.P. Lee, R.E. Manns, Jr., B.D. Taubert, and S.J. Waters. 1991. The status of competitive fishing in North America. Fisheries (Bethesda) 16(3):4-12.

Seidensticker, E.P. 1975. Mortality of largemouth bass for two tournaments utilizing a "don't kill your catch" program. Ann. Conf. Southeast. Assoc. Game and Fish Comm. Proc., 28:83-86.

Van Woert, W.F. 1980. Exploitation, natural mortality, and survival of smallmouth bass and largemouth bass in Shasta Lake, California. Calif. Fish and Game 66:163-171.

Welborn, T.L., Jr., and J.H. Barkley. 1974. Study on the survival of tournament released bass on Ross R. Barnett Reservoir, April 1973. Ann. Conf. Southeast. Assoc. Game and Fish Comm. Proc. 27:512-519.

Whitworth, D. W. 1987. Survey of largemouth bass tournament fishing in Texas: 1985. Texas Parks and Wildlife, Austin, TX. 89 p.

Willis, D.W., and R.F. Hartmann. 1986. The Kansas bass tournament monitoring program. Fisheries (Bethesda) 11(3):7-10.

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Appendix 1. Permit issuance and catch report data for California bass fishing tournaments, 1985-1989.

1985	Permits issued	Days planned	No. reports received	Days fished	No. angler days	Total hours	Total fish	Catch per hour	Number mortalities
Jan	2	2	1 (50.0)[a]	1	117 (117)[b]	1,053 (1,053)[c]	106 (106)[d]	0.101	11 (10.38)[e]
Feb	6	7	0 (0.0)	0	0 (0)	0 (0)	0 (0)	0.000	0 (0.00)
Mar	4	7	2 (50.0)	4	233 (58)	3,042 (761)	568 (142)	0.187	35 (6.16)
Apr	9	11	5 (55.6	6	936 (156)	9,060 (1,510)	1,957 (326)	0.216	30 (1.53)
May	10	12	4 (40.0)	6	438 (73)	6,087 (1,015)	1,582 (264)	0.260	32 (2.02)
Jun	6	7	3 (50.0)	3	322 (107)	2,898 (966)	645 (215)	0.223	35 (5.43)
Jul	2	2	1 (50.0)	1	132 (132)	1,188 (1,188)	232 (232)	0.195	11 (4.74)
Aug	3	3	1 (33.3)	1	92 (92)	828 (828)	90 (90)	0.109	3 (3.33)
Sep	4	4	1 (25.0)	1	72 (72)	648 (648)	187 (187)	0.289	5 (2.67)
Oct	5	6	2 (40.0)	2	143 (72)	1,287 (644)	116 (58)	0.090	2 (1.72)
Nov	5	8	5 (100.0)	8	177 (22)	2,259 (282)	460 (58)	0.204	7 (1.52)
Dec	1	1	1 (100.0)	1	80 (80)	720 (720)	68 (68)	0.094	0 (0.00)
Totals	57	70	26 (45.6)	34	2,742 (81)	29,070 (855)	6,011 (177)	0.207	171 (2.84)
1986									
Jan	8	8	7 (87.5)	7	997 (142)	8,664 (1,238)	513 (73)	0.059	11 (2.14)
Feb	13	13	10 (76.9)	10	1,123 (112)	10,257 (1,026)	1,420 (142)	0.138	39 (2.75)
Mar	22	25	11 (50.0)	1	31,241 (95)	13,464 (1,036)	2,989 (230)	0.222	13 (0.43)
Apr	26	28	12 (46.2)	14	1,599 (144)	14,886 (1,063)	3,723 (266)	0.250	25 (0.67)
May	21	22	12 (57.1)	12	1,599 (133)	14,668 (1,222)	2,048 (171)	0.140	104 (5.08)
Jun	19	22	8 (42.1)	9	1,035 (115)	9,728 (1,081)	1,884 (209)	0.194	67 (3.56)
Jul	13	17	10 (76.9)	13	860 (66)	10,551 (812)	1,209 (93)	0.115	32 (2.65)
Aug	6	7	2 (33.3)	2	243 (122)	2,309 (1,155)	302 (151)	0.131	6 (1.99)
Sep	8	8	3 (37.5)	3	368 (123)	3,450 (1,150)	1,099 (366)	0.319	17 (1.55)
Oct	7	9	1 (14.3)	1	44 (44)	374 (374)	41 (41)	0.110	0 (0.00)
Nov	4	6	2 (50.0)	3	252 (84)	2,558 (853)	429 (143)	0.168	6 (1.40)
Dec	4	4	1 (25.0)	1	11 (11)	88 (88)	6 (6)	0.068	0 (0.00)
Totals	151	169	79 (52.3)	88	9,372 (107)	90,997 (1,034)	15,663 (178)	0.172	320 (2.04)

Appendix 1 cont. Permit issuance and catch report data for California bass fishing tournaments, 1985-1989.

1987	Permits issued	Days planned	No. reports received	Days fished	No. angler days	Total hours	Total fish	Catch per hour	Number mortalities
Jan	7	7	7 (100.0)	7	1,106 (158)	9,964 (1,423)	1,158 (165)	0.116	25 (2.16)
Feb	11	14	10 (90.9)	12	1,393 (116)	13,799 (1,150)	2,754 (230)	0.200	56 (2.03)
Mar	15	17	13 (86.7)	15	1,450 (97)	14,278 (952)	3,957 (264)	0.277	28 (0.71)
Apr	17	20	15 (88.2)	18	2,053 (114)	21,236 (1,180)	6,988 (388)	0.329	92 (1.32)
May	25	26	17 (68.0)	18	1,866 (104)	17,249 (958)	4,516 (251)	0.262	138 (3.06)
Jun	24	32	19 (79.2)	27	1,529 (57)	15,436 (572)	3,336 (124)	0.216	196 (5.88)
Jul	9	11	9 (100.0)	11	1,087 (99)	11,013 (1,001)	1,995 (181)	0.181	45 (2.26)
Aug	13	18	13 (100.0)	18	1,669 (93)	16,939 (941)	3,328 (185)	0.196	96 (2.88)
Sep	9	13	6 (66.7)	9	637 (71)	7,480 (831)	1,712 (190)	0.229	23 (1.34)
Oct	10	12	9 (90.0)	11	621 (56)	5,263 (478)	1,386 (126)	0.263	9 (0.65)
Nov	12	15	12 (100.0)	15	1,138 (76)	10,708 (714)	1,878 (125)	0.175	42 (2.24)
Dec	4	4	4 (100.0)	4	392 (98)	3,160 (790)	356 (89)	0.113	9 (2.53)
Totals	156	189	134 (85.9)	165	14,941 (91)	146,525 (888)	33,364 (202)	0.228	759 (2.27)
1988									
Jan	16	17	16 (100.0)	17	1,409 (83)	12,184 (717)	1,290 (76)	0.106	13 (1.01)
Feb	23	27	21 (91.3)	25	2,629 (105)	28,150 (1,126)	4,387 (175)	0.156	63 (1.44)
Mar	27	30	26 (96.3)	29	2,842 (98)	25,937 (894)	4,972 (171)	0.192	29 (0.58)
Apr	28	32	26 (92.9)	29	2,924 (101)	27,397 (945)	5,761 (199)	0.210	54 (0.94)
May	21	22	19 (90.5)	20	2,605 (130)	24,231 (1,212)	3,404 (170)	0.140	50 (1.47)
Jun	28	33	26 (92.9)	31	2,437 (79)	22,639 (730)	4,037 (130)	0.178	142 (3.52)
Jul	12	14	11 (91.7)	13	588 (45)	5,855 (450)	966 (74)	0.165	18 (1.86)
Aug	15	19	15 (100.0)	19	1,571 (83)	13,620 (717)	3,666 (193)	0.269	55 (1.50)
Sep	17	18	16 (94.1)	17	1,512 (89)	12,610 (742)	2,408 (142)	0.191	35 (1.45)
Oct	20	21	18 (90.0)	19	1,707 (90)	15,319 (806)	2,528 (133)	0.165	21 (0.83)
Nov	16	17	14 (87.5)	14	1,256 (90)	10,177 (727)	1,549 (111)	0.152	17 (1.10)
Dec	11	13	11 (100.0)	13	1,010 (78)	8,815 (678)	1,469 (113)	0.167	16 (1.09)
Totals	234	263	219 (93.6)	246	22,490 (91)	206,934 (841)	36,437 (148)	0.176	513 (1.41)

Appendix 1 cont. Permit issuance and catch report data for California bass fishing tournaments, 1985-1989.

1989	Permits issued	Days planned	No. reports received	Days fished	No. angler days	Total hours	Total fish	Catch per hour	Number mortalities
Jan	14	14	14 (100.0)	14	1,327 (95)	10,572 (755)	1,189 (85)	0.112	51 (4.29)
Feb	23	35	21 (91.3)	33	2,344 (71)	23,498 (712)	2,781 (84)	0.118	43 (1.55)
Mar	28	33	21 (75.0)	24	2,140 (89)	20,288 (845)	3,194 (133)	0.157	32 (1.00)
Apr	32	38	27 (84.4)	32	2,741 (86)	25,805 (806)	6,294 (197)	0.244	109 (1.73)
May	24	25	22 (91.7)	23	2,245 (98)	20,082 (873)	3,214 (140)	0.160	99 (3.08)
Jun	18	24	14 (77.8)	19	1,160 (61)	11,045 (581)	1,933 (102)	0.175	59 (3.05)
Jul	10	13	7 (70.0)	9	485 (54)	4,714 (524)	1,400 (156)	0.297	34 (2.43)
Aug	10	15	8 (80.0)	13	415 (32)	3,076 (237)	1,075 (83)	0.349	27 (2.51)
Sep	19	23	16 (84.2)	18	1,591 (88)	13,341 (741)	2,608 (145)	0.195	26 (1.00)
Oct	26	29	21 (80.8)	23	1,671 (73)	14,634 (636)	3,168 (138)	0.216	16 (0.51)
Nov	12	13	11 (91.7)	12	1,345 (112)	13,177 (1,098)	3,213 (268)	0.244	9 (0.28)
Dec	10	13	9 (90.0)	12	807 (67)	7,621 (635)	1,387 (116)	0.182	3 (0.22)
Totals	226	275	191 (84.5)	232	18,271 (79)	167,853 (724)	31,456 (136)	0.187	508 (1.61)
Grand Totals	824	966	649 (78.8)	765	67,816 (89)	641,379 (838)	122,931 (161)	0.192	2,271 (1.85)

[a] Percent of permits issued in parentheses.
[b] Mean number of anglers per tournament-day in parentheses.
[c] Mean hours of effort per tournament-day in parentheses.
[d] Mean catch per tournament-day in parentheses.
[e] Percent initial mortality in parentheses.

Appendix 2. Estimated effort, catch, and initial mortalities in permitted black bass tournaments in California, 1985-89.

	Month	Estimated total no. angler days	Estimated total no. angler hours	Estimated total catch	Estimated initial mortality
1985					
	Jan	234	2,106	212	22
	Feb	0	0	0	0
	Mar	466	6,084	1,136	70
	Apr	1,683	16,295	3,520	54
	May	1,095	15,218	3,955	80
	Jun	644	5,796	1,290	70
	Jul	264	2,376	464	22
	Aug	276	2,486	270	9
	Sep	288	2,592	748	20
	Oct	358	3,218	290	5
	Nov	177	2,259	460	7
	Dec	80	720	68	0
	Total	5,565	59,149	12,413	359
1986					
	Jan	1,139	9,902	586	13
	Feb	1,460	13,338	1,847	51
	Mar	2,482	26,928	5,978	26
	Apr	3,461	32,221	8,058	54
	May	2,800	25,688	3,587	182
	Jun	2,458	23,107	4,475	159
	Jul	1,118	13,720	1,572	42
	Aug	730	6,934	907	18
	Sep	981	9,200	2,931	45
	Oct	308	2,615	287	0
	Nov	504	5,116	858	12
	Dec	44	352	24	0
	Total	17,487	169,121	31,109	602
1987					
	Jan	1,106	9,964	1,158	25
	Feb	1,532	15,180	3,030	62
	Mar	1,672	16,468	4,564	32
	Apr	2,328	24,077	7,923	104
	May	2,744	25,366	6,641	203
	Jun	1,931	19,490	4,212	247
	Jul	1,087	11,013	1,995	45
	Aug	1,669	16,939	3,328	96
	Sep	955	11,214	2,567	34
	Oct	690	5,848	1,540	10
	Nov	1,138	10,708	1,878	42
	Dec	392	3,160	356	9
	Total	17,244	169,428	39,192	910

Appendix 2 cont. Estimated effort, catch, and initial mortalities in permitted black bass tournaments in California, 1985-89.

	Month	Estimated total no. angler days	Estimated total no. angler hours	Estimated total catch	Estimated initial mortality
1988					
	Jan	1,409	12,184	1,290	13
	Feb	2,880	30,832	4,805	69
	Mar	2,951	26,934	5,163	30
	Apr	3,147	29,491	6,201	58
	May	2,878	26,775	3,761	17
	Jun	2,623	24,369	4,346	153
	Jul	641	6,385	1,053	20
	Aug	1,571	13,620	3,666	55
	Sep	1,607	13,401	2,559	37
	Oct	1,897	17,021	2,809	23
	Nov	1,435	11,631	1,770	19
	Dec	1,010	8,815	1,469	16
	Total	24,050	221,457	38,893	510
1989					
	Jan	1,327	10,572	1,189	51
	Feb	2,567	25,737	3,046	47
	Mar	2,853	27,051	4,259	43
	Apr	3,248	30,575	7,457	129
	May	2,448	21,900	3,505	108
	Jun	1,491	14,197	2,485	76
	Jul	693	6,734	2,000	49
	Aug	519	3,845	1,344	34
	Sep	1,890	15,844	3,097	31
	Oct	2,068	18,111	3,921	20
	Nov	1,467	14,370	3,504	10
	Dec	897	8,468	1,541	3
	Total	21,467	197,403	37,347	600
Grand total		85,813	816,558	158,954	2,981

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DISTRIBUTIONS OF RAINBOW TROUT, LARGEMOUTH BASS AND THREADFIN SHAD IN LAKE CASITAS, CALIFORNIA, WITH ARTIFICIAL AERATION

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Seasonal depth distributions of rainbow trout (*Onchorhynchus mykiss*), largemouth bass (*Micropterus salmoides*), and threadfin shad (*Dorosoma petenense*) were measured during August 1976 through January 1978 with vertical gill nets. Bass occupied shallow, warm water with mean depths mostly <5 m during the summer, but migrated into deeper waters >15 m during the winter when the lake destratified. Trout had the opposite pattern and were found in deep, cold water >20 m during the summer, and in shallow water <10 m during the winter. Shad depth distributions did not have a distinctive pattern. Changes in the diffuser during 1977 caused some minor changes in reservoir oxygen and temperature values, but had no apparent effect on fish depth distributions. Fish depths were more readily explained by considering thermal preferences and predation, with depth selection by bass apparently providing the main force effecting depth selection by shad throughout the year, and winter depth selection by trout. Trout and bass typically selected temperatures and depths closest to their fundamental ecological niche temperatures, but shad never did, apparently in response to predation pressures from bass and trout, especially bass.

INTRODUCTION

Knowledge about fish distributions in lakes and reservoirs, along with related limnological data, can provide valuable fishery management information. These data can provide insights into fishery potentials for different species (Christie and Regier 1988), as well as a basis for predicting or evaluating the effects of certain reservoir management decisions (Beitinger and Fitzpatrick 1979).

Thermal stratification and associated hypolimnetic oxygen depletion of eutrophic lakes is widely known to restrict fish and other biota to shallow depths (Dendy 1945, Bardach 1955, Ziebell 1969). Growth may be reduced with certain warmwater fishes (Mayhew 1963), while coldwater species may suffer habitat loss and high mortalities (Hile 1936, Colby and Brooke 1960, Johnson 1966). Some of the negative effects of stratification and eutrophication can be improved by artificial aeration, either through partial or complete mixing of the entire lake, referred to as destratification, or through hypolimnetic aeration with thermal stratification preserved (Fast 1968, Fast and St. Amant 1971, Fast et al. 1975, Fast 1979).

Lake Casitas, a mesotrophic reservoir located on the Ventura River system near Ventura, California (168 m elevation), is one of the largest reservoirs in southern California storing only native runoff waters for domestic, agricultural, industrial and recreational purposes (Barnett 1979). The lake began storing water during 1959, when the water volume was only 9 x 10^6 m^3. Volume increased to maximum capacity of 313 x 10^6 m^3 during 1978 and overflowed the spillway. During the 1960's, as the lake initially filled, Lake Casitas was eutrophic with hypolimnetic oxygen depletions and anaerobic deep water conditions by early summer each year. In response, the reservoir operators installed a destratification system and operated it seasonally since 1968 (Howard 1972, Barnett 1971, 1979).

As Lake Casitas continued to fill and age, it became less eutrophic. At the same time, the destratification system's ability to mix the lake was greatly reduced due to water volume increases. By 1979, Fast and Hulquist (1982) found that Lake Casitas had one of the lowest air injection to water volume ratios of 11 artificially aerated southern California reservoirs. By 1976, when our present study began, the aging and filling process had continued so that summer dissolved oxygen and temperatures in deep waters were generally >4 mg/L and <19°C, respectively, due to incomplete destratification and lower eutrophication. These conditions produced the most successful "two-story" fisheries (Wilkins et al. 1967) in southern California, with fishing for rainbow trout in deep water, and warmwater species, such as largemouth bass, channel catfish (*Ictalurus punctatus*), and redear sunfish (*Lepomis microlophus*) in shallow water during the summer.

The U.S. Bureau of Reclamation and the lake operator, Casitas Municipal Water District (CMWD), tested a new air diffuser in 1977 to improve aeration efficiency and reduce operating costs. They were concerned, however, that it might negatively affect the summer trout fishery, which led to our present study. We assessed fish distribution during 1976 with the existing air diffuser and during 1977 with the modified diffuser. These observations allowed us to not only evaluate the impacts of diffuser modification, but to make some observations on seasonal depth selections by certain fishes as well.

METHODS

Dissolved oxygen concentrations (DO) and water temperatures were measured weekly during the summer and twice monthly otherwise using a Hydrolab Surveyor (Model 6D). DO and temperatures reported here were measured at up to 19 depths at station 1 (Fig. 1). Fish depths were measured from August 1976 through January 1978 with vertical gill nets similar to those used by Fast (1973) and Miller and Fast (1981). When the aeration system was operating, fish depths were measured monthly at stations 1 through 5, three days each (Fig. 1). During January 1977 and 1978, stations 1 through 3 were sampled monthly for five days each, and during other months, stations 1 through 3 were sampled monthly for two days each. Four 3 m wide gill nets were used at each station, with square mesh sizes of 19, 38, 51, and 89 mm, respectively. Nets were extended from the lake's surface to the bottom and adjusted

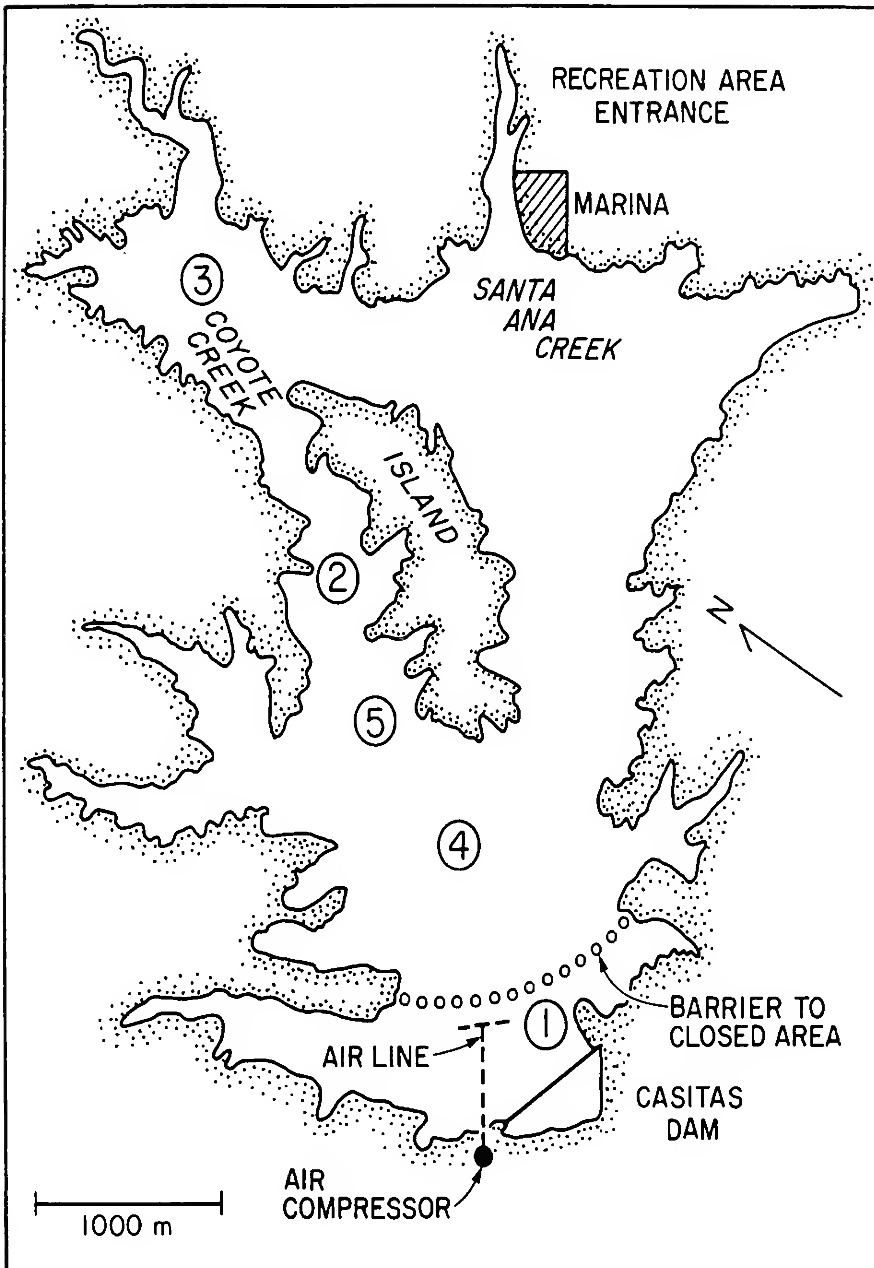

Figure 1. Map of Lake Casitas showing vertical gill net (1 through 5) and water quality (1) sampling stations, and air diffuser line.

for changes in water depth by station and season. Each net was marked at 0.5 m intervals, and fish capture depths were determined to the nearest 0.25 m. Nets were set in the morning and fished for 24 hr before retrieval. Fish were examined for species and capture depth; trout, bass and catfish were also examined for stomach contents.

The aeration system consisted of two 75-HP, shore-based electric air compressors (Fig. 1; Barnett 1979). Each compressor produced 9 m^3/min (315 SCFM) of air. During 1976, air was injected near the dam from four course bubble diffusers consisting of short lengths of iron pipes with holes drilled in the ends, set 21 m apart at water depths between 43 and 49 m. This system produced four discrete, adjacent upwellings. During 1977, the diffuser system was modified into seven lengths of 51 mm ID x 30 m long plastic diffuser pipes, which resulted in a diffuser that was 210 m long (Johnson and LaBounty 1988). Air was injected through 1 mm dia. holes in the pipe at 0.3 m intervals. The diffuser line was suspended at 46 m. Each year, air was injected during April through late October from one or both compressors.

All confidence intervals were at the 95% level *($P < 0.05$)*, while means were compared at the 95% confidence level using the graphical method of Dice and Leraas (1936).

RESULTS

During 1976, thermal stratification began by April 1 (Fig. 2), when vertical temperatures ranged from 14 to 16°C, while DO ranged from 7 to 9.2 mg/l. By June 3, surface temperature exceeded 21°C, with a sharp gradient between 5 and 10 m. DO profiles during June declined gradually from 9.5 mg/l at the surface to 5.5 mg/l at the bottom. The lake gained heat through September 9, when the surface temperature was 24°C, with a sharp gradient between 5 and 10 m, and a gradual decrease from 10 to 45 m. Temperatures increased only slightly below the 45 m air injection depth during the stratified period. DO decreased gradually below 5 m from June through October. The lake began complete destratification during October due to seasonal cooling of surface waters; it was nearly isothermal above 30 m by October 1. By November 29, both temperature and DO were very uniform above 40 m. The lake mixed completely by late December. During 1977, stratification began by April 8 and followed a stratification regime similar to 1976, except for development of strong double thermoclines by August (Fig. 2). One thermocline was between 5 and 10 m and the other was between 45 and 55 m, with a zone of uniform temperature and DO between 10 and 45 m. This condition was most evident on August 26. The lake was still stratified below 55 m on December 20, but was mixed completely by early January 1978.

We captured 1,321 fish with vertical gill nets during 219 sampling days (Table 1). Threadfin shad were most common, comprising 66% of all fish captured. Rainbow trout and largemouth bass comprised 18% and 14% of the catch, respectively, while channel catfish, redear sunfish, and carp (*Cyprinus carpio*) collectively accounted for the remaining 2%.

Rainbow trout were distributed deep during August and September 1976, with

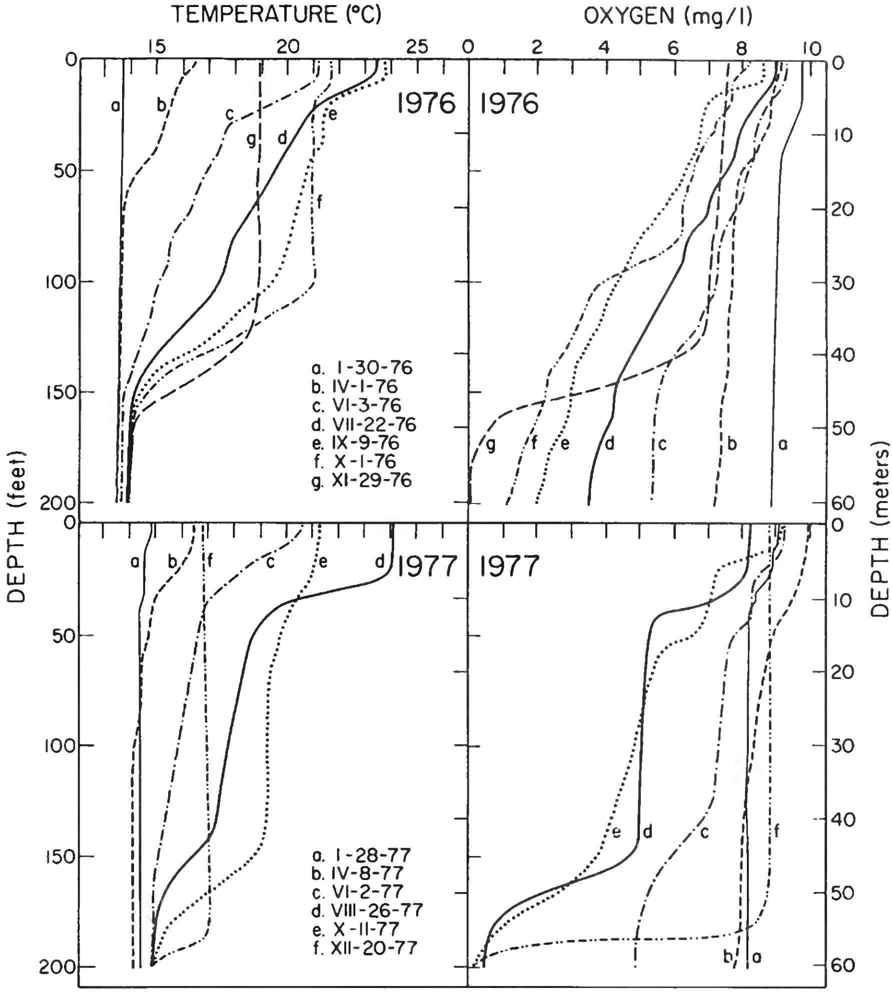

Figure 2. Lake Casitas dissolved oxygen concentrations, water temperatures, and depth at Station 1 during 1976 and 1977.

average capture depths of 28 and 22 m, respectively (Fig. 3). Most trout were captured between 10 and 40 m, while no trout were captured below the 45 m diffuser depth. Their average capture depth decreased during October and November, 1976, as surface waters cooled and the lake destratified. Average trout depths from November 1976 through January 1977 ranged from 4 to 7 m. These mean depths were not significantly different, but were significantly less than mean depths during August through October 1976. By February 1977, average trout depth began to increase again. By April 1977, mean depth was >20 m, and was significantly deeper than during the previous November/January. There were no significant differences in mean trout

Table 1. Summary of all fish captured in vertical gill nets at Lake Casitas each month from August 1976 through January 1978.

	1976		1977				1978	
	A/S	O/N/D	J/F/M	A/M/J	J/A/S	O/N/D	J	Total
Threadfin shad	39	18	59	275	313	132	35	871
Rainbow trout	39	12	43	55	52	18	16	235
Largemouth bass	10	19	39	57	20	29	6	180
Channel catfish	0	3	7	9	1	0	7	27
Redear sunfish	0	0	1	2	0	2	2	7
Carp	0	0	0	0	0	1	0	1
Total	88	52	149	398	386	182	66	1,321

depth from April through August 1977, with means between 20 and 28 m. Trout depths during August and September, 1976 and 1977, were not significantly different. There was a gradual upward trend in trout depths from June 1977 through January 1978, but depth decreases were not as abrupt as during the fall 1976.

Seasonal distribution of largemouth bass mean capture depths was nearly the inverse of trout. During September 1976, mean bass depth was 6 m, and was significantly less than trout (Fig. 3). During October 1976, bass depth increased, while trout depths decreased with no significant differences between the two species. From November 1976 through January 1977, bass were found deep and trout shallow, with significant differences each month between the two. During February through April 1977, bass depths decreased from >20 to 5 m. From April through September 1977, their mean depth was always <10 m, significantly less than for trout. From September through November 1977, bass depths increased from 7.5 to 25 m, but then decreased abruptly to only 5 m during December 1977 and January 1978.

Seasonal depth patterns for threadfin shad were not as cyclic as for trout and bass. Shad mean capture depths were generally deeper than 20 m, but on four dates were 15 m or less. On 11 of 17 sample dates, average shad depths were greater than either trout or bass. Shad mean capture depth sometimes varied widely from month to month. From August through November 1976, their depths ranged from <10 to 40 m.

While bass and shad are self-perpetuating populations, trout do not reproduce at Lake Casitas. All trout were hatchery-reared and stocked during the cooler months. During October 1976 through May 1977, 84,800 trout (12,700 kg) were stocked, while during October 1977 through January 1978, 61,950 trout (9,663 kg) were stocked. Average lengths and weights were 240 mm and 152 g (3 fish/lb), respectively. Monthly mean lengths and weights of trout captured in the gill nets ranged from 305 mm and 320 g, to 420 mm and 1,000 g. Mean trout sizes in gill nets were lowest during times when hatchery trout were stocked in large numbers. The largest angler-caught trout during our study weighed 2,950 g (Sasaki 1979).

Rainbow trout were most often captured in gill nets at deep water station 1, except

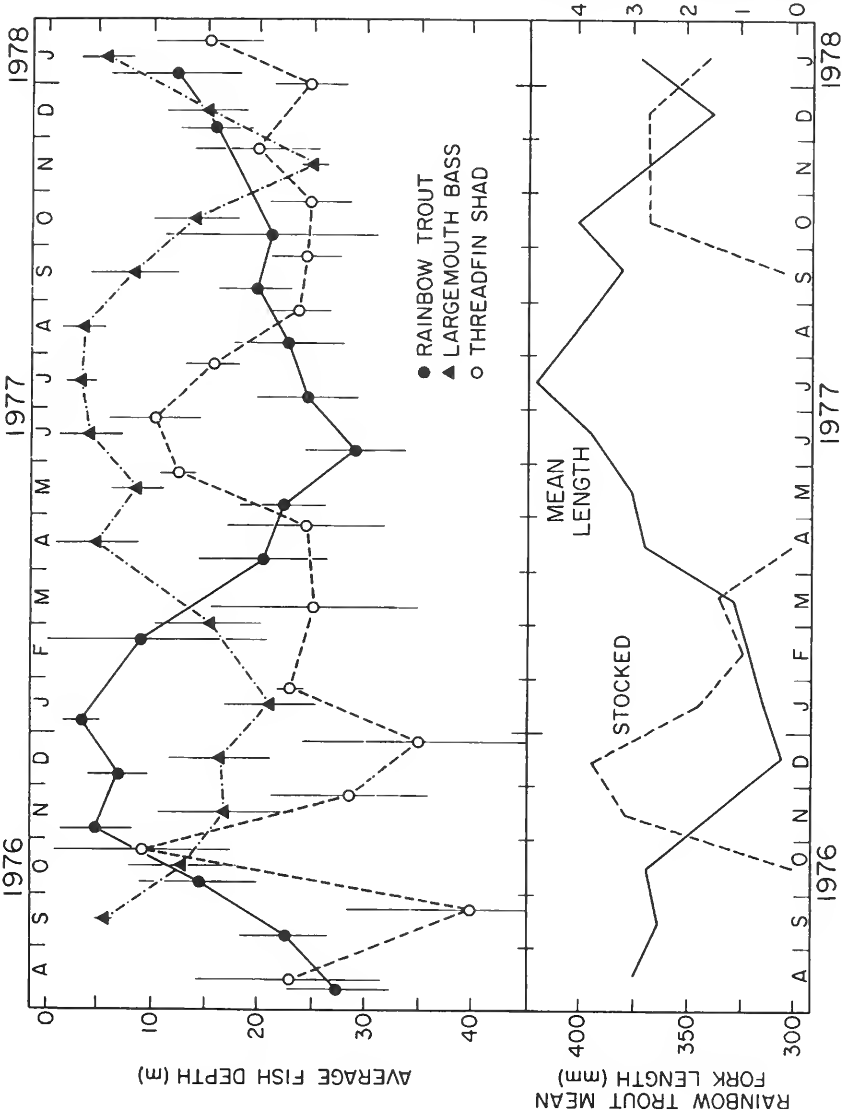

Figure 3. Average capture depths in Lake Casitas for rainbow trout, largemouth bass and threadfin shad during August 1976 through January 1978, with 95% confidence intervals. Fish depths are for all sampling stations combined. Also shown are average fork lengths of trout captured in gill nets, and total weight of hatchery-reared trout stocked in the lake by month.

during August/September 1976, when they were most abundant at station 2, and during January/March 1977, when they were most abundant at shallow station 3. Largemouth bass were always most numerous at station 3. Threadfin shad were never abundant at station 1, and were most numerous at stations 2 and 3.

Threadfin shad were the predominant food item for trout and bass. Of those trout and bass which had any food in their stomachs (62%), shad occurrence was 96% and 97%, respectively. Only 4 of 110 trout fed on crayfish and insects, while only 2 of 68 bass fed on crayfish. Channel catfish had a more varied diet, feeding more on crayfish. Gill net capture rates for catfish and sunfish were too low to provide meaningful assessments of their depth distributions.

DISCUSSION

Air diffuser modification caused differences in summer temperature and DO depth profiles during 1977 compared with 1976; but these changes had little apparent effect on summer depth distributions of the fishes. There were no significant differences in mean depth distributions of bass, trout or shad during August, September or October 1977, compared with 1976. This project was initiated, at least in part because of concern that diffuser modifications might negatively impact Casitas' trophy trout fishery, and in particular reduce habitat available to trout during summer months. If we assume that trout habitat, with respect to temperature and DO, can be defined by waters ≤20°C and ≥4 mg/l respectively (Wilkins et al. 1967, Axon 1971), we saw little difference during the critical late summers of 1976 and 1977, when water with these qualities comprised between 50% and 60% of the lake's volume each year. The aeration system had no measurable effect on shallow water habitat.

Seasonal depth distributions of trout and bass, and especially of their principal prey species, threadfin shad, are perhaps of greater interest. Seasonal depth distributions for trout and bass in Lake Casitas were nearly the inverse of each other. Trout were in deep water during the summer and in shallow water during the winter. Just the opposite occurred with bass. On the other hand, shad followed a less distinct seasonal depth pattern, perhaps due to predator avoidance.

While many factors can influence fishes' depth selections, temperature is one of the most important (Ferguson 1958, Brett 1971, Christie and Regier 1988), and can in part help explain our observations at Lake Casitas. Two temperature related concepts are relevant to our consideration of temperature-depth selection; those of fundamental ecological niche (Magnuson et al. 1979), which is the temperature within which conditions for growth, metabolism and certain other functions are optimal for a fish species (McCauley and Casselman 1981, Jobling 1981), and a fish's final preferendum temperature (FPT), or that temperature towards which a fish species will ultimately gravitate in an unrestricted environment (Fry 1947). Fundamental ecological niche is usually taken as FPT ± 2°C, and of course assumes that DO and/or some other factors are not otherwise limiting. FPT is measurable in the laboratory. Measured rainbow trout FPT's range from 11.3 to 19.2°C, with a 16°C average (Garside and Tait 1958, Javaid and Anderson 1967, McCauley and Pond 1971, Cherry et al. 1975, 1977,

McCauley et al. 1977). This is a wide range, reflecting large differences in trial conditions. Average FPT for trout yields fundamental ecological niche temperatures of 14 to 18°C. Measured largemouth bass FPT's are more consistent, ranging from 29 to 32°C, with a 29.7°C average (Ferguson 1958, Neill and Magnuson 1974, Reynolds et al. 1976, Reynolds and Casterlin 1978, Venables et al. 1978). This yields a niche range of 27 to 32°C for bass.

FPT is unmeasured for threadfin shad, but can be approximated from measured relationships between maximum spawning temperatures (MST) and maximum growth temperatures (MGT) for 17 species where both values were measured (U.S. Environmental Protection Agency [EPA] 1976). This relationship is described by $y = 16.2 + 0.65x$ ($r = 0.83$, $n = 17$), where y = maximum growth temperature (°C), and x = maximum spawning temperature (°C). If we use x = 18°C for threadfin shad (U.S. EPA 1976, Hubbs and Bryan 1974), this yields a maximum growth temperature of 28°C. Corresponding maximum growth temperatures for trout and bass were 19 and 32°C respectively, which are 3 and 2.3°C above their respective FPT. By inference then, shad FPT is about 25°C, with fundamental ecological niche temperatures of 23 to 27°C; which agrees with Coutant's (1977) classification of threadfin shad as a "high preferenda" species.

Maximum water temperatures at Lake Casitas seldom exceeded even the minimum niche temperature for largemouth bass, and were normally between 24 and 25°C (Fig.'s 2 and 4). When thermal stratification was ≥2°C, bass tended to select water temperatures and depths within 1°C of their maximum. This is most evident during the summer 1977, when bass were typically found at <5 m in water temperatures within 1°C of their maximum (Fig.'s 3 and 4). This could be interpreted as an attempt to seek their niche temperatures. However, it does not explain their movement into deep water following thermal destratification each fall. Although this phenomenon has been observed elsewhere (Cady 1945, Dendy 1945, 1946a, 1946b, 1948, May and Gloss 1979), the cause has not been explained; perhaps bass are seeking prey. Since there is little or no thermal advantage for staying in shallow water, they disperse into the depths. Their primary prey species, threadfin shad, were almost always found much deeper than bass at Lake Casitas (Fig. 4).

Rainbow trout, during periods of thermal stratification generally occupied waters of 15 to 21°C with ≥4 mg/l DO (Fig. 4). This approximates their niche temperature of 14 to 18°C, and it explains their presence in water depths mostly >20 m during the summer; however, it does not explain their movement into water <10 m following thermal destratification. Although there is no thermal advantage to remaining in deep water following destratification, simple dispersion, as presented for bass, would indicate a deeper distribution than the upper 10 m. Fast (1971) observed movement of rainbow trout into deeper water in a Michigan lake following complete mixing and isothermal conditions. There were no predators on trout in this Michigan lake, which was also food limited. I suggest that the Lake Casitas trout occupied deep water during the summer for thermal reasons, but that they occupied shallow water during the winter to avoid threat of predation by bass, as bass moved into deeper water in search of their primary prey, threadfin shad. Although we did not observe predation by bass

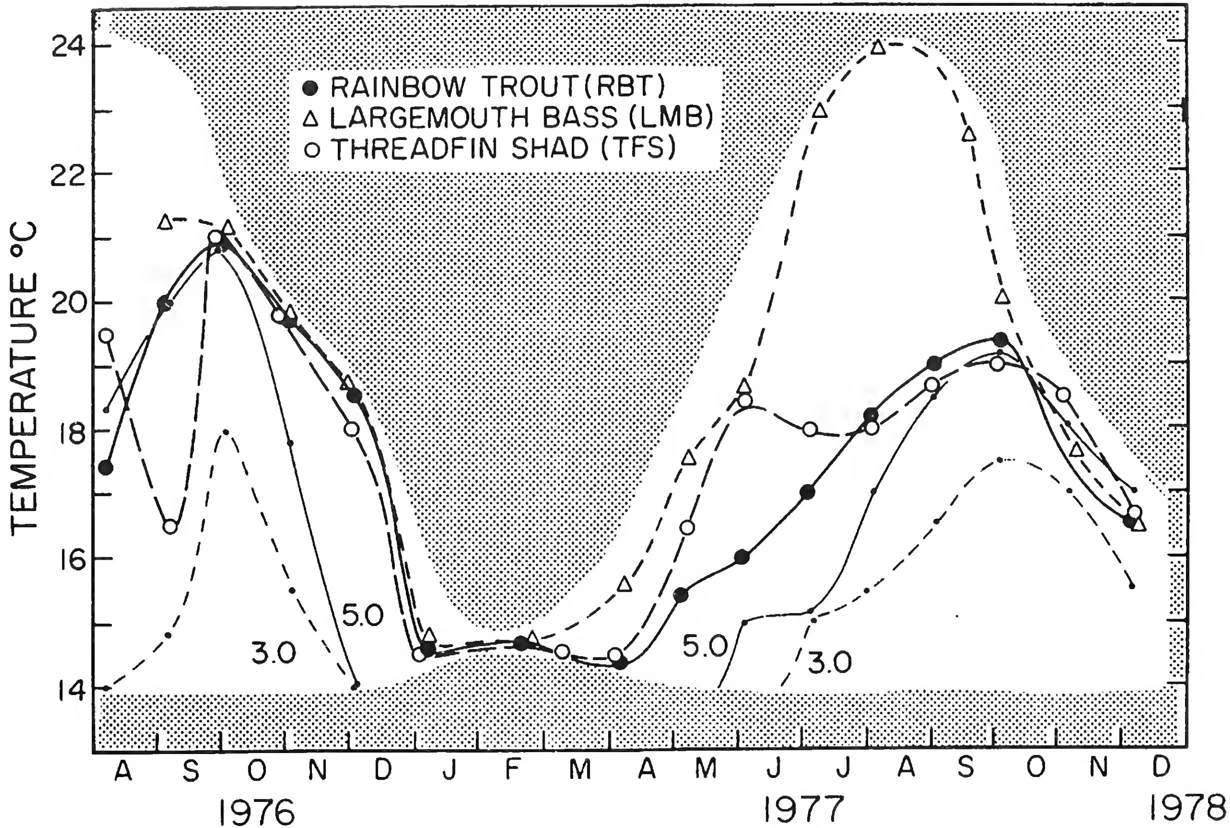

Figure 4. Maximum (lake surface) and minimum (lake bottom) water temperatures at Lake Casitas during 1976 and 1977; which are illustrated by the area between the shaded portions. Monthly water temperatures at average depths for largemouth bass, threadfin shad and rainbow trout are shown. Also shown are the 3.0 and 5.0 mg/l dissolved oxygen isopleths.

on trout in our stomach analyses, larger bass will readily feed on trout (McAfee 1966, Axon 1971). Even the "primordial" threat of predation, or some other interspecific interaction other than predation, may be sufficient to cause avoidance behavior of bass by trout.

An alternative, or perhaps complementary hypothesis for shallow water depth distributions of trout during winter, is that large numbers of smaller, hatchery-reared trout were stocked during this time, from October through April or May each year (Fig. 3). These fish were conditioned at the hatchery to feed at the surface, a behavior which may have extended to the lake. Horak and Tanner (1964), von Geldern (1964) and May and Gloss (1979) have all observed movements of rainbow trout into shallow depths following seasonal destratification, which in some cases was attributed to their feeding on natural food items.

Threadfin shad depth selections at Lake Casitas are more difficult to explain on the basis of thermal niche. If their fundamental niche lies in or near 23 to 27°C, we see that their distribution at Lake Casitas gives little evidence that they sought these temperatures (Fig.'s 3 and 4). They were more often found at water temperatures <19°C and depths >20 m, even when shallow waters exceeded 24°C. Threadfin shad are known to prefer warm, shallow waters (Parsons and Kimsey 1954, Netsch et al. 1971, Coutant 1977, Coutant and Carroll 1980), yet at Lake Casitas they preferred cold, deep waters during most of the year. I suggest the reason for this is predation by both trout and bass on the shad, but especially by bass. Stomach analyses of bass and trout at Lake Casitas showed that 96% to 97% of all food items in their stomachs were shad. Shad are well known to be highly preferred food items of bass (Goodson 1965, Burns 1966, Wilkins et al. 1967, von Geldern and Mitchell 1975). Further evidence at Lake Casitas has to do with respective significant differences in mean fish depths. On those dates when sufficient numbers of bass and trout were captured to provide a 95% confidence interval, the ratio of significantly different:non-significantly different mean depths for trout/bass was 2:1, or 67% of the time bass and trout had different mean depths ($P < 0.05$; Fig. 3). This can be explained in part by respective thermal niche requirements, but as mentioned above, avoidance of bass by trout may have also played a major role. The ratio of significantly different:non-significantly different mean depths for bass/shad was 1.3:1, or, on 56% of the dates, their respective mean depths were different. I attribute this mostly to avoidance of bass by shad, especially given their respective similarities in niche temperatures, and observed abnormally deep and cold depth selections by shad. Mean depth ratio for trout/shad was 0.8:1, or on 44% of the dates their mean depths were significantly different. I interpret this to mean that shad also attempted to avoid predation by trout, but to a lesser extent than with bass.

In summary, I conclude that bass, trout and shad depth distributions at Lake Casitas were primarily related to a combination of thermal preferences and predation. The main driving force for bass and trout depth selections during the summer was thermal niche considerations. During the winter, predation, or threat thereof, by bass on trout largely determined trout depth selection. Depth selection by shad appeared to be driven throughout the year by predation threats from both bass and trout, but

especially bass; this predation largely overwhelmed the shad's temperature preferences.

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LITERATURE CITED

Axon, J.R. 1971. An evaluation of the trout fishery in Lake Cumberland, Kentucky. Pages 235-242 *in* G.E. Hall, ed. Reservoir Fisheries and Limnology. Spec. Publ. No. 8, American Fish. Soc., Washington, D.C.

Bardach, J.E. 1955. Certain biological effects of thermocline shifts. Hydrobiologia 7:309-324.

Barnett, R.H. 1971. Reservoir destratification improves water quality. J. Public Works June:60-65.

______. 1979. Case study of reaeration of Casitas Reservoir. Pages 4-17 *in* Proceedings, Symposium on Reaeration Research. Amer. Soc. of Civil Engineers.

Beitinger, T.L., and L.L. Fitzpatrick. 1979. Physiological and ecological correlates of preferred temperature in fish. Amer. Zool. 19:319-329.

Brett, J.R. 1971. Energetic response of salmon to temperature: a study of some thermal relations in the physiology and freshwater ecology of sockeye salmon (*Oncorhynchus nerka*). Amer. Zool. 11:99-113.

Burns, J.W. 1966. Threadfin shad. Pages 481-488 *in* A. Calhoun, ed. Inland Fisheries Management. Calif. Fish & Game, Sacramento, Calif.

Cady, E.R. 1945. Fish distributions, Norris Reservoir, Tennessee, 1943, I. Depth Distribution of fish in Norris Reservoir. Rept. Reelfoot Lake Biol. Station 9:103-114.

Cherry, D.S., K.L. Dickson, and J. Cairns, Jr. 1975. Temperatures selected and avoided by fish at various acclimation temperatures. J. Fish. Res. Bd. Canada 32:495-491.

______, ______, ______, and J.R. Stauffer. 1977. Preferred, avoided and lethal temperatures of fish during rising temperature conditions. J. Fish. Res. Bd. Canada 34:239-246.

Christie, G.C., and H.A. Regier. 1988. Measures of optimal thermal habitat and their relationship to yields for four commercial fish species. Canad. J. Fish Aquatic Sci. 45:301-314.

Colby, P.J., and L.T. Brooke. 1969. Cisco (*Coregonus artedii*) mortalities in a southern Michigan lake, July 1968. Limnol. Ocean. 14(6):958-960.

Coutant, C.C. 1977. Compilation of temperature preference data. Fish. Res. Bd. Canada 34:739-745.

______, and D.S. Carroll. 1980. Temperatures occupied by ten ultrasonic-tagged striped bass in freshwater lakes. Amer. Fish. Soc. Trans. 109:195-202.

Dendy, J.S. 1945. Fish distributions, Norris Reservoir, Tennessee, 1943, II., Depth distribution of fish in relation to environmental factors, Norris Reservoir. Rept. Reelfoot Lake Biol. Station 9:114-135.

______. 1946a. Water temperature and spring fishing, Norris Reservoir, Tennessee. Rept. Reelfoot Lake Biol. Station 10:89-93.

______. 1946b. Further studies of depth distribution of fish, Norris Reservoir, Tennessee. Rept. Reelfoot Lake Biol. Station. 10:94-104.

______. 1948. Predicting depth distributions of fish in three TVA storage type reservoirs. Amer. Fish Soc., Trans. 75:65-71.

Dice, L.R., and H.J. Leraas. 1936. A graphical method for comparing several sets of measurements. Contr. Lab. Vert. Gen., Univ. Michigan. 3:1-3.

Fast, A.W. 1968. Artificial destratification of El Capitan Reservoir by aeration, part I, effects on the chemical and physical parameters. Calif. Dept. Fish and Game, Fish Bull. 141. 97p.

______. 1971. The effects of artificial aeration on lake ecology. Water Poll. Cont. Res. Ser. 16010 EXE 12/71. U.S.Environmental Protection Agency, Washington, D.C. 470 p.

______. 1973. Effects of artificial hypolimnion aeration on rainbow trout (*Salmo gairdneri*) depth distributions in a northern Michigan lake. Amer. Fish. Soc. Trans. 102(4):715-722.

______. 1979. Artificial aeration as a lake restoration technique. Pages 121-131 *in* Lake Restoration, Proceedings of a National Conference. U.S. Environmental Protection Agency, Washington, D.C. EPA 440/5-79=001.

______, and J. St. Amant. 1971. Nighttime artificial aeration of Puddingstone Reservoir, Los Angeles County, California. Calif. Fish Game 57:213-216.

______, V.A. Dorr, and R.J. Rosen. 1975. A submerged hypolimnion aerator. Water Resources Research 11(2):287-293.

______, and R.G. Hulquist. 1982. Supersaturation of nitrogen gas caused by artificial aeration of reservoirs. Tech. Rept. E-82-9. U.S. Army Corp. of Engineers, Vicksburg, 136 p.

Ferguson, R.G. 1958. The preferred temperature of fish and their mid-summer distribution in temperate lakes and streams. J. Fish. Res. Bd. Canada 15:607-624.

Fry, F.E.J. 1947. Effects of environment on animal activity. Ont. Fish. Res. Lab. Publ. 68:1-62.

Garside, E.T., and T.S. Tait. 1958. Preferred temperature of rainbow trout (*Salmo gairdneri* Richarson) and its unusual relationship to acclimation temperature. Canadian J. Zool. 36:563-567.

Goodson, L.F. 1965. Diets of four warmwater game fishes in a fluctuating, steep-sided California reservoir. Calif. Fish Game 51(4):259-269.

Hile, R. 1936. Age and growth of the cisco, *Leucichthys artedii,* (LeSuer), in the lakes of the northeastern highlands, Wisconsin. U.S. Bureau of Fisheries Bull. 48:211-217.

Horak, D.L., and H.A. Tanner. 1964. The use of gill nets in studying fish depth distributions, Horsetooth Reservoir, Colorado. Amer. Fish. Soc., Trans. 93(2):137-145.

Howard, R.G. 1972. Reservoir destratification improves water quality. Reclamation ERA: a Water Rev. Quart. (Feb):6-7.

Hubbs, C., and C. Bryan. 1974. Maximum incubation temperature of the threadfin shad, *Dorosoma petenense*. Amer. Fish. Soc. Trans. 103(2):369-371.

Javaid, M.Y., and J.M. Anderson. 1967. Influence of starvation on selected temperature of some salmonids. J. Fish. Res. Bd. Canada 24:1515-1519.

Jobling, M. 1981. Temperature tolerance and the final preferendum: rapid methods of the assessment of optimum growth temperatures. J. Fish. Biol. 19:439-455.

Johnson, R.C. 1966. The effects of artificial circulation on production in a thermally stratified lake. Wash. Dept. Fish., Fish. Res. Paper 2(4):5-15.

Johnson, P.L., and J.F. LaBounty. 1988. Optimization of multiple reservoir uses through reaeration-Lake Casitas, U.S.A. A case study. Comm. Internationale Des Grands Barrages, San Francisco. Q.60,R27:437-451.

Magnuson, J.J., L.B. Crowder, and P.A. Medvick. 1979. Temperature as an ecological resource. Amer. Zool. 19:331-343.

May, B.E., and S.P. Gloss. 1979. Depth distribution of Lake Powell fishes. Publ. No. 78-1, Utah State Div. Wildlife Resources, Ogden, Utah. 19 p.

Mayhew, J. 1963. Thermal stratification and its effects on fish and fishing in Red Haw Lake, Iowa. Biol. Sec. State Conservation Comm. 24 p.

McAfee, W.R. 1966. Rainbow trout. Pages 192-215 *in* A. Calhoun, ed. Inland Fisheries Management. Calif. Dept. Fish and Game, Sacramento, Calif.

McCauley, R.W., and W.L. Pond. 1971. Temperature selection of rainbow trout fingerlings in vertical and horizontal gradients. J. Fish. Res. Bd. Canada 28:1801-1804.

______, J.R. Elliot, and A.L.A. Read. 1977. Influence of acclimation temperature on preferred temperature in the rainbow trout, *Salmo gairdneri*. Amer. Fish. Soc. Trans. 106:362-65.

______, and J.M. Casselman. 1981. The final preferendum as an index of the temperature for optimum growth in fish. Pages 81-93 *in* K. Tiews, ed. Proceedings of the World Symposium on Aquaculture in Heated Effluents and Recirculation Systems. Heenemann Verlagsgesellschaft, Berlin.

Miller, L.W., and A.W. Fast. 1881. The effects of artificial destratification on fish depth distribution in El Capitan Reservoir, California. Pages 498-514 *in* F.L. Burns and I.J. Powling, eds. Destratification of lakes and reservoirs to improve water quality. Australian Govern. Publishing Service, Canberra.

Neill, W.H., and J.J. Magnuson. 1974. Distributional ecology and behavioral thermoregulation of fishes in relation to heated effluent from a power plant at Lake Monona, Wisconsin. Amer. Fish. Soc. Trans. 103:663-710.

Netsch, N.F., G.M. Kersh, Jr., A. Houser, and R.V. Kilambi. 1971. Distribution of young gizzard and threadfin shad in Beaver Reservoir. Pages 95-105 *in* G.E. Hall, ed. Reservoir Fisheries and Limnology. Spec. Publ. No. 8, American Fisheries Society, Washington, D.C.

Parsons, J.W., and J.B. Kimsey. 1954. A report on the Mississippi threadfin shad. Prog. Fish-Cult. 16:179-182.

Reynolds, W.W., R.S. McCauley, M.E. Casterlin, and L.I. Crawshaw. 1976. Body temperatures of behaviorally thermoregulating black bass (*Micropterus salmoides*). Comp. Biochem. Physiol 54A:461-463.

______, and M.E. Casterlin. 1978. Complementary of thermoregulator rhythms in *Micropterus salmoides* and *M. dolomieui*. Hydrobiologia 60:89-91.

Sasaki, S. 1979. Creel census study at Lake Casitas, Ventura County, California. Calif. Dept. Fish and Game, Long Beach. 45 p.

U.S. Environmental Protection Agency. 1976. Quality criteria for water. U.S. Government Printing Office, Washington, D.C. p. 218-244.

Venables, B.J., L.C. Fitzpatrick, and W.D. Pearson. 1978. Laboratory measurement of preferred body temperatue of adult largemouth bass (*Micropterus salmoides*). Hydrobiol. 58:33-36.

von Geldern, Jr., C.E. 1964. Distribution of white catfish, *Ictalurus catus*, and rainbow trout, *Salmo gairdneri*, in Folsom Lake, California, as determined by gill netting from February through November 1961. Calif. Dept. Fish and Game, Sacramento, Calif. Inland Fish. Admin. Rept. No. 64-15. 8 p.

______, and D.F. Mitchell. 1975. Largemouth bass and threadfin shad in California. Pages 436-449 *in* H. Clepper, ed. Black bass biology and management. Sport Fishery Institute, Washington, D.C.

Wilkins, P., L. Kirkland, and A. Hulsey. 1967. The management of trout fisheries in reservoirs having a self-sustaining warm water fishery. Pages 444-452 *in* Reservoir Fishery Symposium, American Fisheries Soc., Washington, D.C.

Ziebell, C.D. 1969. Fishery implications associated with prolonged temperature and oxygen stratification. J. Arizona Acad. Sci. 514:258-262.

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ENVIRONMENTAL CONTAMINANTS IN CANVASBACKS WINTERING ON SAN FRANCISCO BAY, CALIFORNIA

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The concentrations of 11 trace elements, 21 organochlorines, 13 polycyclic aromatic hydrocarbons, and 13 aliphatic hydrocarbons were determined in canvasbacks (*Aythya valisineria*) wintering on San Francisco Bay, California during 1988. With the exception of Se, concentrations of potentially toxic elements were low. Similarly, concentrations of most organic compounds were near or below detection limits. Aliphatic hydrocarbons, PCBs, and DDE were common, but at levels lower than those known to be harmful to waterfowl. Innocuous trace elements (Cu, Fe, and Zn), which are often associated with anthropogenic contamination, occurred at high levels. Concentrations of toxic elements were several times lower and those of benign elements were similar or greater than concentrations reported for surf scoters (*Melanitta perspicillata*) or greater scaup (*Aythya marila*) from San Francisco Bay.

INTRODUCTION

Canvasback (*Aythya valisineria*) populations have declined in North America since 1980 and remain at low levels (Office of Migratory Management, Laurel, MD. unpubl. data). This decline is particularly evident in California where habitat degradation is associated with a proliferation of agriculture, urbanization, and industry. The consequent release of large amounts of anthropogenic contaminants may contribute to the decline of canvasbacks, but few corroborating data are available (Ohlendorf and Fleming 1988). About 83% of the canvasbacks that inhabit western North America are estimated to overwinter for 4-6 months in California, primarily in San Francisco Bay (Reinecker 1985). This estuary is now a focus of national concern because of loss of wildlife habitat and the historical and contemporary discharge of large quantities of contaminants (Gunther *et al.* 1987).

Concentrations of certain trace elements in San Francisco Bay waterfowl are higher than those of most other North American estuaries. Concentrations of selenium (Se), silver (Ag), cadmium (Cd), copper (Cu), mercury (Hg), and zinc (Zn) were higher in diving ducks collected from San Francisco Bay than in those in the same or

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similar species obtained in Chesapeake Bay, Maryland (Ohlendorf *et al.* 1986a). Surf scoters (*Melanitta perspicillata*), greater scaup (*Aythya marila*), and canvasbacks from San Francisco Bay had substantially higher concentrations of Se than individuals of the same species from coastal California sites (White *et al.* 1988, Ohlendorf *et al.* 1989). Concentrations in livers of the surf scoters were similar to those in dabbling ducks (*Anas* spp.) from the San Joaquin Valley, California, where severely impaired reproduction was correlated with elevated Se (Ohlendorf *et al.* 1986b). Concentrations of Hg in scoters and scaup from the Bay were higher than concentrations in mallards (*Anas platyrhynchos*) that had been fed a diet containing 0.5 μg/g (parts per million) Hg for three generations (Heinz 1979).

Spatial and temporal variations in metal concentrations also have been documented in diving ducks from San Francisco Bay (Ohlendorf *et al.* 1989, 1991). Surf scoters collected from northern San Francisco Bay had higher Se and lower Hg and Cd concentrations than scoters from the southern half of the Bay. Concentrations of Se in scoters and scaup increased from late fall to early spring and from earlier to later years (White *et al.* 1988, Ohlendorf *et al.* 1989). Increases in Hg concentrations occurred in scoters at some sites between early and late winter, and also between 1982 and 1985 (Ohlendorf *et al.* 1989).

The objective of this study was to determine concentrations of a wide spectrum of trace elements, organochlorines, and both aliphatic and polycyclic aromatic hydrocarbons in canvasbacks wintering on San Francisco Bay.

METHODS

Canvasbacks were collected near Alameda and Alviso in southern San Francisco Bay and near China Camp, Day Island, and Tubbs Island in the northern Bay during March and April 1988 (Fig. 1). Sites were selected where large numbers of canvasbacks congregated. We attempted to collect 6 of each sex at each of the south Bay sites and 4 of each sex at each north Bay site. Actual numbers collected varied because of the difficulty in collecting or concerns about excessive sampling. Nineteen canvasbacks were obtained at the 2 south Bay sites and 23 at the 3 north Bay sites; 25 females and 17 males were collected. Ducks were collected using shotguns loaded with steel shot, and were aged (Serie *et al.* 1982), sexed, weighed, and dissected the same day. Feathers were clipped from each bird and the liver, kidneys, and a 10-g sample of skin and subcutaneous fat tissue were removed. Tissues were placed in separate certified clean jars and frozen. The remaining carcass was eviscerated, reweighed, and frozen.

Liver and kidney samples were analyzed for elements by U.S. Fish and Wildlife Service (USFWS) chemists at the Patuxent Wildlife Research Center in Laurel, Maryland. Kidneys were analyzed for Cd, and livers for Hg and Se, using graphite furnace atomic absorption spectrophotometry (Krynitsky 1987, Haseltine *et al.* 1981). Livers were analyzed for aluminum (Al), arsenic (As), Cd, chromium (Cr), Cu, iron (Fe), nickel (Ni), lead (Pb), and Zn using the dry ash procedure described by Haseltine *et al.* (1981) and inductively coupled plasma emission spectrophotometry.

Carcasses were analyzed for organochlorines, and skin and fat samples for

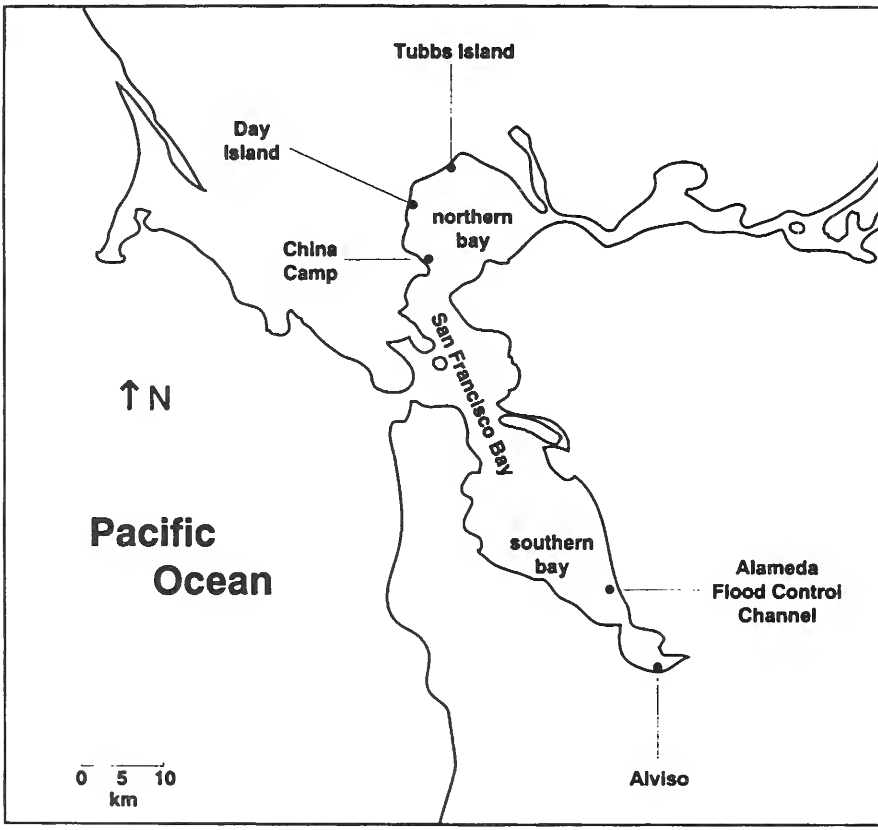

Figure 1. Sites in San Francisco Bay, California, where canvasback ducks were collected for determination of contaminants, 1988.

aliphatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) by the Mississippi State University Chemical Laboratory (Mississippi State, Mississippi). Organochlorine compounds analyzed were total PCBs and the following pesticides (or their metabolites): *alpha*-chlordane, *gamma*-chlordane, *cis*-nonachlor, *trans*-nonachlor, heptachlor epoxide, oxychlordane, dieldrin, endrin, HCB (hexachlorobenzene), alpha-BHC (1,2,3,4,5,6-hexachlorocyclohexane), beta-BHC, gamma-BHC, delta-BHC, mirex, p,p'DDT, o,p'DDT, p,p'DDD, o,p'DDD, p,p'DDE, o,p'DDE, and toxaphene. Analytical procedures are described by Haseltine *et al.* (1981). Residues were quantified by gas chromatography.

Aliphatic hydrocarbons analyzed were n-dodecane, n-tridecane, n-tetradecane, n-pentadecane, n-hexadecane, n-heptadecane, n-octadecane, n-nonadecane, n-eicosane, phytane, pristane, octylcyclohexane, and nonylcyclohexane. Polycyclic aromatic hydrocarbons analyzed were naphthalene, fluorene, phenanthrene, anthracene, fluoranthrene, pyrene, 1,2-benzanthracene, chrysene, benzo (b) fluoranthrene, benzo (k) fluoranthrene, benzo (a,e) pyrene, 1,2,5,6-dibenzanthracene, and benzo (g,h,i)

perylene. Ten grams of tissue were digested in 6N potassium hydroxide, cooled, neutralized with glacial acetic acid, extracted with methylene chloride, dehydrated, reconstituted in petroleum ether, and transferred to a 20-g, 1% deactivated silica gel column topped with 5 g of neutral alumina. Aliphatic hydrocarbons and PAHs were separated by sequential elution with petroleum ether, methylene chloride-petroleum ether solution, and methylene chloride. Additional concentration and elution steps were taken for aliphatic hydrocarbons as necessary, with a Florisil column and a diethyl ether-petroleum ether solution. Hydrocarbons were quantified by capillary column, flame ionization gas chromatography and fluorescence high performance liquid chromatography.

All chemical analyses were performed under the quality assurance and control program of the USFWS. The nominal detection limit was 0.01 µg/g for Hg, most organochlorine pesticides, aliphatic hydrocarbons, and PAHs; 0.05 µg/g for toxaphene and PCBs; 0.10 µg/g for As, Cd, Cr, Cu, and Se; 0.2 µg/g for Pb; 0.4 µg/g for Ni; and 1.0 µg/g for Al, Fe, and Zn.

Differences in contaminant concentrations (log transformed) between either sex or regions (i.e., northern and southern bay) were determined by 2-way analysis of variance (ANOVA); numbers of ducks collected were not sufficiently large to permit analysis by age, site, or sex within site. A Kruskal-Wallis ranking test determined whether adults tended to have higher concentrations of contaminants than younger age ducks. Correlations between body weight and residue concentration were evaluated by simple regression. If <50% of the samples were below detection limits for a specific chemical, those samples were assigned a value one-half the nominal detection limit and included in the ANOVA; if >50%, the chemical data were not analyzed statistically and a geometric mean was not calculated. Concentrations of elements are reported in dry weight (Adrian and Stevens 1979) and average moisture content is provided. Organic compounds are reported in wet weight.

RESULTS

The 11 targeted trace elements were detected in canvasbacks, but the frequency of occurrence varied. Mercury, Se, Fe, Cu, and Zn were above detection limits in all liver samples; the remaining elements occurred less frequently (Table 1). Concentrations of Cu ($P = 0.04$), Fe ($P = 0.0001$), and Hg ($P = 0.006$) were higher in canvasbacks from the south bay than in those from the north bay sites; As occurred in higher ($P = 0.0001$) concentrations in canvasbacks from the north bay. Cadmium in kidneys was higher ($P = 0.01$) in female than male specimens, but only in the north bay. Mean concentrations of trace elements in livers did not differ between sexes. Canvasbacks at each of the sites had 2 or 3 trace elements that were higher in mean concentration than the remaining sites. Ducks containing the highest individual concentrations of metals were collected near Day Island (Al, Cr, Cu, Fe, Se, Zn), Alameda (liver Cd, Ni, Pb), and Tubbs Island (As, Hg). Each element occurred at highest levels in different individuals, except for Al and Zn.

Eight of the 21 organochlorine compounds were detected above nominal limits in

Table 1. Geometric mean and maximum individual concentrations (µg/g, dry wt.) of trace elements detected in liver and kidney (Cd only) of 42 canvasbacks collected from San Francisco Bay, California, March - April 1988. Mean percent moisture in the livers = 69.5 (SD ± 2.0). Frequency of occurrence in parentheses.

	n	Al (5%)	As (69%)	Cd (liver) (81%)	Cd (kidney) (95%)	Cr (45%)	Cu (100%)
Mean, all	42	--[a]	0.25	0.56	2.30	--	99.1
Maximum	1	120	1.1	5.8	9.5	13	600
North bay	23	--	0.51[b]	0.72	2.40	--	80
South bay	19	--	0.11	0.42	2.22	--	129[b]
Male	17	--	0.25	0.71	1.97	--	101
Female	25	--	0.25	0.48	2.59[c]	--	97.9

	n	Fe (100%)	Hg (100%)	Ni (26%)	Pb (55%)	Se (100%)	Zn (100%)
Mean, all	42	618	3.09	--	0.43	13.2	160
Maximum	1	5040	25.0	3.5	5.8	40	270
North bay	23	368	2.24	--	0.45	14.3	165
South bay	19	1154[b]	4.57[b]	--	0.41	12.0	154
Male	17	720	3.98	--	0.71	13.5	162
Female	25	557	2.61	--	--	13.0	158

[a] Mean not calculated because >50% of the samples were below detection limits.
[b] Significant difference, $P < 0.05$, 2-way ANOVA (e.g., As analysis indicates north bay concentrations significantly higher than south bay, but no sex difference).
[c] Interaction: females > males in north bay only.

>50% of the carcass samples (Table 2). Mean concentrations of 6 compounds were higher in ducks collected from the south bay than those from the north bay; however, individual ducks with the highest concentrations of heptachlor epoxide and dieldrin were from the north bay sites. Total PCBs and DDE occurred most frequently and the highest concentrations of these were in a single duck from the Alviso site. The highest concentrations of DDT and DDD also occurred in a single individual from the Alviso site. Organochlorine concentrations did not differ between male and female specimens.

Seven of 13 PAHs were detected, but only fluorene, naphthalene, and phenanthrene occurred in >50% of the canvasbacks collected; therefore mean concentrations of the remaining 10 PAHs were not calculated (Table 2). The 3 common PAHs detected were higher in ducks collected from the south bay than those from the north bay. Levels of PAHs did not differ between sexes.

All 13 aliphatic hydrocarbons were detected and 10 occurred in >50% of the ducks (Table 2). Overall mean concentrations ranged from 0.05 to 0.15 µg/g. Two of these hydrocarbons were higher in ducks collected from the north bay than those from the south bay and 1 was higher in the south bay. Two aliphatic hydrocarbons were higher

Table 2. Geometric mean and maximum individual concentrations (µg/g, wet wt.) of organochlorine (in carcass) and other hydrocarbon compounds (in skin and fat) detected in tissue of 42 canvasbacks collected from San Francisco Bay, California, March - April, 1988. Average percent moisture was 61.5 (SD ± 5.4) in carcasses and 32.5 (SD ± 14.4) in skin and fat samples. Average lipid content in the skin and fat samples was 15.7 (SD ± 7.3).

Organochlorine compounds	Freq. of occurrence (%)	Mean	Maximum	North bay	South bay
n		42	1	23	19
Total PCBs	100	1.079	4.80	0.694	1.840[b]
Trans-nonachlor	79	0.013	0.06	0.009	0.018[b]
Heptachlor epoxide	74	0.012	0.11	0.008	0.020[b]
Oxychlordane	71	0.011	0.05	--[a]	0.016
Dieldrin	76	0.017	0.09	0.010	0.031[b]
p,p'DDT	59	0.011	0.04	--	0.019
p,p'DDD	81	0.012	0.04	0.010	0.014[b]
p,p'DDE	100	0.386	1.60	0.289	0.548[b]
Polycyclic aromatic hydrocarbons					
n		42	1	23	19
1,2-Benzanthracene	14	--	0.01	--	--
Chrysene	26	--	0.02	--	--
Fluoranthrene	24	--	0.02	--	--
Fluorene	81	0.010	0.02	0.008	0.012[b]
Napthalene	81	0.018	0.04	0.013	0.027[b]
Phenanthrene	76	0.022	0.09	0.017	0.032[b]
Pyrene	26	--	0.01	--	--
Aliphatic hydrocarbons					
n		42	1	23	19
n-Dodecane	100	0.116	0.47	0.120	0.112
n-Tridecane	100	0.067	0.11	0.069	0.065
n-Tetradecane	100	0.098	0.43	0.117[b]	0.078
n-Pentadecane	100	0.092	0.18	0.095	0.088
n-Hexadecane	100	0.056	0.16	0.057	0.055
n-Heptadecane	100	0.154	1.40	0.126	0.195[b]
n-Octadecane	100	0.065	0.16	0.070[b]	0.059
				Male	Female
n		42	1	17	25
n-Nonadecane	93	0.046	0.28	0.044	0.047
n-Eicosane	17	--	0.67	--	--
Phytane	100	0.074	0.83	0.058	0.087[c]
Pristane	98	0.056	0.82	0.037	0.073[c]
Octylcyclohexane	40	--	0.04	--	0.013
Nonylcyclohexane	43	--	0.06	--	0.012

[a] Mean not calculated because >50% of the samples were below detection limits.
[b] Significant difference, $P < 0.05$, 2-way ANOVA, between north and south bays; no significant differences between sex for organochlorines, polycyclic aromatic hydrocarbons, and some aliphatic hydrocarbons.
[c] Significant difference between sex, no difference between north and south bays.

in female than male ducks. The highest concentrations in individual ducks were 2 to 11 times greater than overall mean concentrations. The highest concentrations of most aliphatic hydrocarbons were grouped in just a few individuals.

Sixty-four percent of the 42 canvasbacks were adults, 24% subadults, and 12% juveniles. There was no pattern indicating that adults had a greater frequency or tendency of higher concentrations of trace elements or compounds than subadults or juveniles, or that subadults had a greater frequency of higher concentrations than juveniles ($P \geq 0.05$).

Male canvasbacks weighed more than females ($P = 0.004$), therefore correlations between body weight and contaminant burden were analyzed separately by sex. Most of the n-paraffinic aliphatic hydrocarbons were inversely correlated with body weight, primarily in male ducks: n-tridecane (males, $r^2 = 0.64$, $P = 0.0001$; females, $r^2 = 0.19$, $P = 0.03$), n-tetradecane (males, 0.79, 0.0001; females, 0.44, 0.0003), n-pentadecane (males, 0.74, 0.0001; females, 0.24, 0.01), n-hexadecane (males, 0.81, 0.0001; females, 0.41, 0.04), n-octadecane (males, 0.62, 0.0002), and n-nonadecane (males, 0.61, 0.0002). Correlations for the remaining elements and compounds were not significant.

DISCUSSION

Selenium concentrations detected in this study were comparable to levels (on a dry wt. basis, assuming about 70% moisture) reported in canvasbacks in 1987 (White *et al.* 1988). Mean concentrations of Se were within the range associated with impaired reproduction in waterfowl. Female mallards fed diets containing 8 and 16 µg/g organic Se had between 8.0 and 24.3 µg/g Se (on a dry wt. basis) in their livers and produced fewer eggs, malformed embryos, or low duckling survival compared to control mallards (Heinz *et al.* 1989). Whether Se is harmful to reproduction in canvasbacks wintering on San Francisco Bay probably depends on the interval of time between leaving the Bay and breeding. Heinz and Fitzgerald (in press) reported that reproductive success returned to normal about 2 weeks after exposure to Se ended. From studies relating dietary levels of Se to liver concentrations (e.g., Heinz *et al.* 1989), dietary Se levels (15 µg/g) associated with mortality in winter-stressed ducks probably were greater than the levels to which canvasbacks were exposed on San Francisco Bay (Heinz and Fitzgerald, in press). Also, the effect of temperature in winter is probably minimal on San Francisco Bay because of the mild climate and abundant prey.

Mean concentrations of Hg in livers of these canvasbacks were slightly lower than that in mallards (about 4.5 µg/g Hg, dry wt.) fed 0.5 µg/g methylmercury in their diets (Heinz 1979). These mallards were reproductively impaired and produced young that had altered behavior. Concentrations of Hg in canvasbacks from San Francisco Bay were probably at background levels, that is, comparable to that in wild birds from areas considered minimally contaminated with mercury (Fimreite 1974). However, higher levels of mercury in waterfowl have been reported for San Francisco Bay (Ohlendorf *et al.* 1986a, 1989). Any potential effects of Hg may have been offset by the presence

of relatively high Se concentrations (El-Begearmi *et al.* 1977).

Available information on effects of Cd indicate that adult mallards were unaffected by dietary levels of 200 μg/g Cd; these mallards had about 110 μg/g Cd in their livers and 134 g/g Cd in their kidneys after 60 days (White and Finley 1978; White *et al.* 1978; Heinz *et al.* 1983). Based on White and Finley's (1978) study, the canvasbacks we report probably were exposed to a dietary intake of < 20 μg/g Cd. Mean concentrations of Cd in livers of canvasbacks from San Francisco Bay were less than the 3 μg/g Cd that is considered background for waterfowl (Scheuhammer 1987). Concentrations of Pb were probably less than that which might adversely affect health of waterfowl (Finley *et al.* 1976), and Cr was uncommon or at low concentrations.

Elemental concentrations in these canvasbacks differed from those in other diving ducks wintering on San Francisco Bay. Mean concentrations of Cd, Hg, and Se were 1.5-10 times higher (not statistically compared) in scaup and surf scoters than in canvasbacks, whereas Pb was 2-3 times higher in canvasbacks (Ohlendorf *et al.* 1986a, 1989). Concentrations of Cu and Zn were similar in canvasbacks and scaups and 1.3-2 times higher than those in surf scoters. These differences may be attributed to differences in prey or feeding areas. Mean levels of Cd (2 times), Hg (10 times), and Se (3 times) were higher in canvasbacks from San Francisco Bay than those from a relatively uncontaminated hunting area in Louisiana, whereas levels of Cu, Pb, and Zn were similar or higher in Louisiana (Custer and Hohman unpubl. data).

Concentrations of most chlorinated compounds in these canvasbacks are probably not harmful. However, sublethal effects of many of these contaminants are not well known for waterfowl. Mean concentrations of PCBs and DDE were several times greater than detection limits, and were similar or higher in both frequency and concentration than that in surf scoters from San Francisco Bay (Ohlendorf *et al.* 1991). However, concentrations detected in our study indicated low exposure. Toxic dietary levels of PCBs for adult mallards were greater than 2,500 μg/g (tissue concentrations were not measured; Heath *et al.* 1972). Mallards fed 25.0 μg/g of a potentially toxic PCB aroclor (1254) had mean liver concentrations of 55.3 (females) and 64.2 μg/g (males) with no effects on reproduction (Custer and Heinz 1980). PCB concentrations in potential bivalve prey of canvasbacks from San Francisco Bay measured less than 2.2 μg/g, dry wt. (Long *et al.* 1988). Black ducks (*Anas rubripes*) fed 10 μg/g DDE for 7 months had severe reproductive impairment but no mortality (Longcore and Stendell 1977). These black ducks had 15 times the dietary level of DDE in their carcasses. The mean concentration of DDE in canvasbacks from San Francisco Bay was <1.0 μg/g.

Polycyclic aromatic hydrocarbons in canvasbacks from this study probably are not at harmful concentrations. The 3 of 13 PAHs that were common were only slightly above minimum detection limits. Ducks apparently have good metabolic detoxification mechanisms for removal of ingested hydrocarbons (McEwan and Whitehead 1980). Mallards fed diets containing 0.40% PAHs (4,000 μg/g, that included naphthalenes and phenanthrene) and 0.60% aliphatic hydrocarbons for 7 months exhibited increased liver weights but no overt signs of toxicity; tissue concentrations were not measured (Patton and Dieter 1980). These dietary levels are far greater the 0.02 to 14.0 μg/g

PAHs measured in mussels from San Francisco Bay (Long *et al.* 1988).

Aliphatic hydrocarbons were more common than PAHs but also occurred at concentrations that are probably nontoxic to ducks. Adult mallards fed a reconstituted mixture composed of 10 aromatic and 9 aliphatic compounds at a dietary level of 400 µg/g for 6 months showed no apparent physiological impairments, including weight loss, but tissue concentrations were not reported (Stickel and Dieter 1979). In our study, increased concentrations of n-paraffin hydrocarbons were inversely correlated with body weight in canvasbacks. Mallards fed diets of 0.96% n-paraffin hydrocarbons and 0.04% PAHs and 0.60% n-paraffin hydrocarbons and 0.40% PAHs had weight losses during the first 3 months but returned to pretreatment weights by 7 months (Patton and Dieter 1980). The greater weight loss was in the higher PAH diet. Reduced gain in mass in herring gulls (*Larus argentatus*) was correlated with aromatic hydrocarbon fractions but not aliphatic fractions (Miller *et al.* 1982).

The distribution of higher concentrations of contaminants indicated that all age groups were probably equally exposed (that is, adult canvasbacks were not likely to accumulate more contaminants at higher concentrations than young canvasbacks). The tendency toward high exposure across all age groups indicated that the concentrations of contaminants observed probably were acquired on San Francisco Bay during the wintering period. Therefore, adults were not bioaccumulating contaminants over time or during the breeding or migratory periods.

Concentrations of some elements and most chemical compounds in canvasbacks from San Francisco Bay indicated low exposure to anthropogenic contaminants. Declining canvasback numbers in the western United States are not directly attributable to contaminants acquired by populations wintering in San Francisco Bay. After reaching record low levels in 1988, there are recent indications that canvasback populations may be rebounding in San Francisco Bay (Harvey et al. 1992). However, evidence of high and increasing Se levels and elevated Hg levels warrant future monitoring. Moreover, other species of diving ducks in the Bay with similar habitat requirements contained substantially higher levels of certain toxic elements.

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LITERATURE CITED

Adrian, W.J., and M.L. Stevens. 1979. Wet versus dry weights for heavy metal toxicity determinations in duck liver. J. Wildl. Dis. 15:125-126.

Custer, T.W., and G.H. Heinz. 1980. Reproductive success and nest attentiveness of mallards fed Aroclor 1254. Environ. Pollut. 21:313-318.

El-Begearmi, M.M., M.L. Sunde, and H.E. Ganther. 1977. A mutual protective effect of mercury and selenium in Japanese quail. Poult. Sci. 56:313-322.

Fimreite, N. 1974. Mercury contamination of aquatic birds in northwestern Ontario. J. Wildl. Manage. 38:120-131.

Finley, M.T., M.P. Dieter, and L.N. Locke. 1976. Sublethal effects of chronic lead ingestion in mallard ducks. J. Toxicol. Environ. Health. 1:929-937.

Gunther, A.J., J.A. Davis, and D.J.H. Phillips. 1987. An assessment of the loading of toxic contaminants to the San Francisco Bay-Delta. Aquatic Habitat Institute, Richmond, Calif. 330 p.

Harvey, T.E., K.J. Miller, R.L. Hothem,, M.J. Rauzon, G.W. Page, and R.A. Keck. 1992. Status and trends report on wildlife of the San Francisco Bay estuary. Report for the San Francisco Bay project, U.S. Environ. Protect. Agency, San Francisco, Calif. 283 p + appendices.

Haseltine, S.D., G.H. Heinz, W.L. Reichel, and J.F. Moore. 1981. Organochlorine and metal residues in eggs of waterfowl nesting on islands in Lake Michigan off Door County, Wisconsin, 1977-78. Pestic. Monit. J. 15:90-97.

Heath, R.G., J.W. Spann, E.F. Hill, and J.F. Kreitzer. 1972. Comparative dietary toxicities of pesticides to birds. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Wildl. 152. 57 p.

Heinz, G.H. 1979. Methylmercury: reproductive and behavorial effects on three generations of mallard ducks. J. Wildl. Manage. 43:394-401.

______, and M.A. Fitzgerald. in press. Reproduction of mallards following overwintering exposure to selenium. Environ. Pollut.

______, S.D. Haseltine, and L. Sileo. 1983. Altered avoidance behavior of young black ducks fed cadmium. Environ. Toxicol. Chem. 2:419-421.

______, D.J. Hoffman, and L.G. Gold. 1989. Impaired reproduction of mallards fed an organic form of selenium. J. Wildl. Manage. 52:418-428.

Krynitsky, A.J. 1987. Preparation of biological tissue for determination of arsenic and selenium by graphite furnace atomic absorption spectrometry. Anal. Chem. 59:1884-1886.

Long, E., D. MacDonald, M.B. Matta, K. VanNess, M. Buchman, and H. Harris. 1988. Status and trends in concentrations of contaminants and measures of biological stress in San Francisco Bay. NOAA Tech. Memorand. NOS OMA 41. 268 p.

Longcore, J.R., and R.C. Stendell. 1977. Shell thinning and reproductive impairment in black ducks after cessation of DDE dosage. Arch. Environ. Contam. Toxicol. 6:293-304.

McEwan, E.H., and P.M. Whitehead. 1980. Uptake and clearance of petroleum hydrocarbons by the glaucous-winged gull (*Laras glaucescens*) and the mallard duck (*Anas platyrhynchos*). Can. J. Zool. 58:723-726.

Miller, D.S., D.J. Hallett, and D.B. Peakall. 1982. Which components of crude oil are toxic to young seabirds? Environ. Toxic. Chem. 1:39-44.

Ohlendorf, H.M., and W.J. Fleming. 1988. Birds and environmental contaminants in San Francisco and Chesapeake bays. Mar. Pollut. Bull. 19:487-495.

______, R.W. Lowe, P.R. Kelly, and T.E. Harvey. 1986a. Selenium and heavy metals in San Francisco Bay diving ducks J. Wildl. Manage. 50:64-71.

______, D.J. Hoffman, M.K. Saiki, and T.W. Aldrich. 1986b. Embryonic mortality and abnormalities of aquatic birds: apparent impacts of selenium from irrigation drainwater. Sci. Total Environ. 52:49-63.

______, K.C. Marois, R.W. Lowe, T.E. Harvey, and P.R. Kelly. 1989. Environmental contaminants and diving ducks in San Francisco Bay. Pages 61-69 *in* Howard, A.Q., ed. Selenium and agricultural drainage: implications for San Francisco Bay and the California environment. Proc. 4th Selenium Symp. Bay Instit. S.F. Bay, Sausalito, Calif.

______, ______, ______, ______, and ______. 1991. Trace elements and organochlorines in surf scoters from San Francisco Bay, 1985. Environ. Monitor. Assess. 18:105-122.

Patton, J.F., and M.P. Dieter. 1980. Effects of petroleum hydrocarbons on hepatic function in the duck. Comp. Biochem. Physiol. 65C:33-66.

Reinecker, W.C. 1985. An analysis of canvasbacks banded in California. Calif. Fish Game 71:141-149.

Scheuhammer, A.M. 1987. The chronic toxicity of aluminum, cadmium, mercury, and lead in birds: a review. Environ. Pollut. 46:263-295.

Serie, J.R., D.L. Trauger, H.A. Doty, and D.E. Sharp. 1982. Age-class determination of canvasbacks. J. Wildl. Manage. 46:894-904.

Stickel, L.F., and M.P.Dieter. 1979. Ecological and physiological effects of petroleum on aquatic birds. U.S. Fish Wildl. Serv. FWS/OBS-79/23. 14 p.

White, D.H., and M.T. Finley. 1978. Uptake and retention of dietary cadmium in mallard ducks. Environ. Res. 17:53-59.

______, ______, and J.F. Ferrell. 1978. Histopathological effects of dietary cadmium on kidneys and testes of mallard ducks. J. Toxicol. Environ. Health 4:551-558.

White, J.R., P.S. Hofmann, D. Hammond, and S. Baumgartner. 1988. Selenium verification study, 1987: a report to the State Water Resources Control Board. Calif. Department of Fish and Game, Sacramento. 60 p + appendices.

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CALIFORNIA FISH AND GAME

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OCCURRENCE OF THE CODLING (*HALARGYREUS JOHNSONII*, MORIDAE), IN THE EASTERN NORTH PACIFIC

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This report documents the occurrence of *Halargyreus johnsonii* (Gunther, 1861), a codling, caught 20 March 1990 during a study of catch composition in the northern California deep-water trawl fishery, and represents the fourth recorded capture of *H. johnsonii* in the eastern North Pacific.

The specimen was caught in a commercial bottom trawl at approximately 980 m depth 33 naut. miles (nm) off the Klamath River (lat 41°25'N, long 124°50'W), and was catalogued in the HSU Fisheries Collections (HSU 90-04). Other eastern North Pacific capture locations are: 850 nm west of Vancouver Island at lat 50°N, long 145°W (NMC 76-0031) (Peden et al. 1985); 160 nm southwest of Monterey Bay at lat 35°13'N, long 121°41'W (SIO 88-98); and 35 nm off southern Washington at lat 45°03'N, long 124°54'W (SIO 89-53). The latter two specimens were loaned to us by the Scripps Institution of Oceanography (SIO) for examination.

H. johnsonii was first described by Günther (1861) from a specimen taken off Madeira in the eastern North Atlantic. Specimens have been collected in temperate waters of the North Atlantic (Templeman 1968), South Atlantic (Permitin 1969), South Pacific (Cohen 1973), and off Japan (Kanayama, et al., 1978). Nelson (1984) comments that *H. johnsonii* seems to present a "remarkable case of disjunct distribution." *H. johnsonii* is said to be benthopelagic or pelagic in habit and has been collected as shallow as 508 m in the western South Atlantic (Paulin 1983) to greater than 1500 m in the western North Atlantic (Cohen 1973).

Our specimen agrees with Templeman's (1968) diagnosis of the genus, with "lower jaw extending beyond the upper jaw; a small tubercle or symphyseal knob on the lower jaw symphysis; no chin barbel; vomer and palatine without teeth; head scales to tip of snout; a free caudal peduncle; and one anal and two dorsal fins, with the anal fin deeply notched."

Based on measurements and counts reported in Templeman (1968), Cohen (1973) chose not to propose subspecific status for regional populations of *H. johnsonii*. We concur, based on our comparison of body proportions (Table 1). Ranges of meristic counts (Fig. 1) may show patterns of variation between North Atlantic, southern hemisphere, and North Pacific specimens, but overlap widely.

Table 1. Selected body proportions of eastern North Pacific and Japanese specimens of *Halargyreus johnsonii* compared to ranges reported for North and South Hemispheres.

	Eastern North Pacific					Hemisphere[b]	
Musuem	HSU-	SIO-	SIO-	HUMZ-	IFES-[a]	North	South
Number	90-04	89-53	88-98	69320	593	$n = 30$	$n = 31$
Standard length	455	395	236	421	414		
	Percent of Standard Length					Range	
Head length	26.4	26.8	28.8	27.3	25.9	23.6-27.6	23.3-26.7
Pre-dorsal I	29.4	29.4	31.6	29.5	29.8	27.2-30.3	25.7-29.8
Depth at vent	11.9	13.2	10.6	15.7	15.1	10.5-16.8	10.2-15.5
Snout	6.8	6.8	7.2	7.0	6.7	5.8-8.7	6.4-8.1
Orbit	6.2	6.3	7.2	6.1	5.9	5.2-8.1	6.0-7.8
Upper jaw	12.1	11.9	12.7	13.0	12.1	11.3-13.7	10.7-12.7
Inter-orbital	5.5	5.8	5.9	6.3	5.9	4.6-6.3	4.4-6.4

[a] Recalculated from Kanayama et al. (1978).
[b] From Cohen (1973). Does not include North Pacific specimens.

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LITERATURE CITED

Cohen, D.H. 1973. The gadoid fish genus *Halargyreus* (Family Eretmophoridae) in the Southern Hemisphere. Journal of the Royal Society of New Zealand 3(4): 629-634.

Günther, A. 1861. Catalogue of the Acanthopterygian fishes in the collection of the British Museum. Vol. 3-4. British Museum, London.

Kanayama, T., T. Sasaki, and H. Sasaki. 1978. Discovery of the Morid Fish *Halargyreus johnsonii* in the Western North Pacific. Japanese Journal of Ichthyology 25(1): 68-70.

Nelson, J.S. 1984. Fishes of the World. John Wiley and Sons, New York. 523 p.

Paulin, C.D. 1983. A revision of the Family Moridae (Pisces: Acanthini) within the New Zealand region. National Museum of New Zealand Records 2(9): 81-126.

Peden, A.E., W. Ostermann, and L.J. Pozar. 1985. Fishes observed at Canadian Weathership Ocean Station Papa (50°N 145°W) with notes on the TransPacific Cruise of the CSS Endeavor. British Columbia Provincial Museum Heritage Record No. 18.

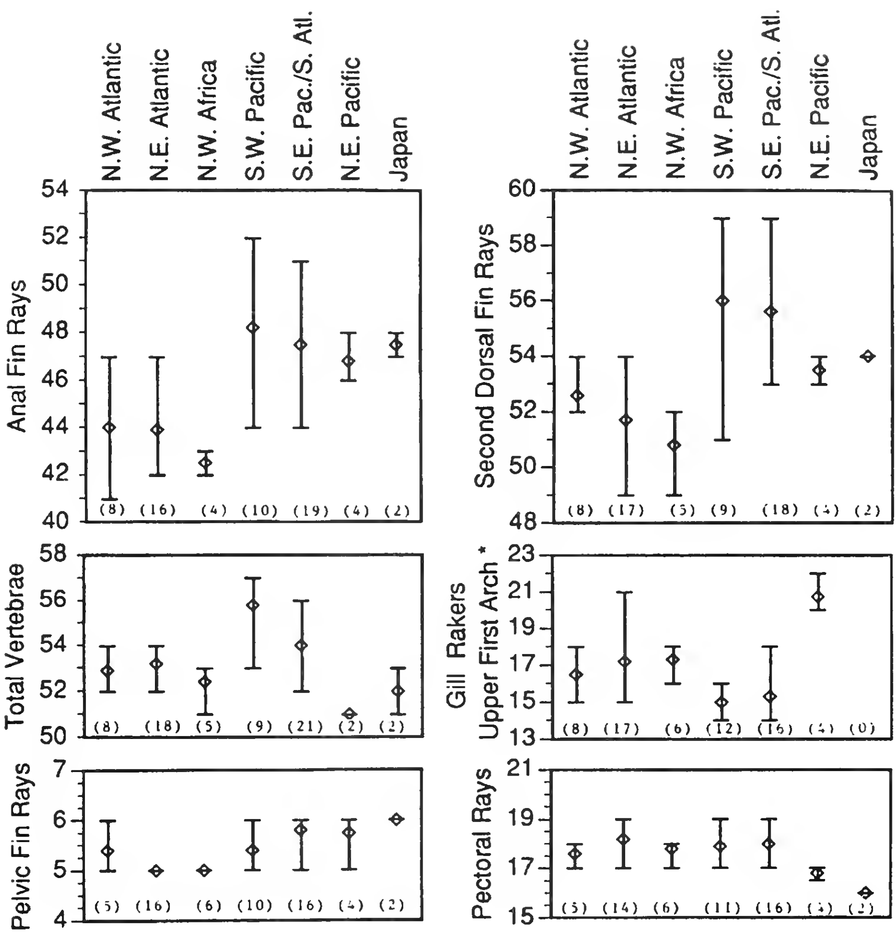

Figure 1. Range and mean of selected meristic counts for *Halargyreus johnsonii* by region of capture. Sample sizes are listed below ranges.

Permitin, Y. 1969. New data on species composition and distribution of fishes in the Scotia Sea (Second communication). Journal of Ichthyology 9(1): 167-81.

Templeman, W. 1968. A review of the morid fishes genus *Halargyreus* with first records from the Western North Atlantic. J. Fish. Res. Bd. Can. 25(5): 877-901.

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COMMENTS ON RESEARCH, PUBLICATIONS, AND CALIFORNIA'S LONGEST CONTINUOUSLY PUBLISHED JOURNAL

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Eric R. Loft (1992) indirectly brought to the forefront some frustrations felt by many wildlife and fisheries biologists employed by the California Department of Fish and Game (CDFG). Historically, CDFG employees were leaders in the fields of fisheries and wildlife research and management, as evidenced by the extensive number of their publications that appeared in *California Fish and Game* for several decades. As Loft aptly noted, "The journal flourished with technical and informative articles from many Department personnel on fish and wildlife during the 1950s-1960s."

I concur with Loft's contention that a greater number of CDFG employees should publish their research in *California Fish and Game*, and would encourage publication in other appropriate journals, as well. Unfortunately, however, opportunities for employees to conduct meaningful research have diminished significantly in the past two decades (Loft 1992). During my CDFG career, any professional papers I have authored, whether published in *California Fish and Game* or elsewhere, resulted from efforts put forth above and beyond the duties listed in my job descriptions, rather than as part of them. Likewise, I suspect that the majority of recent professional papers authored by other CDFG employees, whether or not they appeared in *California Fish and Game*, were prepared in addition to the duties outlined in their job descriptions. Until the Department acknowledges that research is part of its mission, instead of something to be done when time permits, the literature will not benefit from increased contributions by CDFG scientists.

The current Director of CDFG has expressed a desire to see the Department become more respected in the scientific community (Loft 1992). Despite the talents and abilities possessed by many CDFG employees, almost all research sponsored by CDFG is carried out by universities or private contractors. Indeed, CDFG invests hundreds of thousands of dollars annually in contract studies that involve little more on behalf of CDFG than a transfer of funds. Soule and Wilcox (1980) noted the need for increased cooperation between academic and applied scientists, a sentiment strongly echoed by Bleich (1981). At the very least, CDFG-sponsored research should, by definition, be collaborative in nature and fully involve appropriate CDFG scientists. Such a policy would increase the number of contributions to the literature by CDFG scientists and, thereby, enhance the Department's professional image.

CDFG administrators must realize the benefits, both political and scientific, of enhancing opportunities for employees to contribute to the understanding of how "...California's fish, wildlife, and native plants interact with each other, with their

habitats, and with human-induced impacts" (Loft 1992). Until such is the case, frustrations will remain high, submittal rates will remain low, and contractors and university employees will continue to dominate the literature pertaining to fish and wildlife in California.

A lack of scientific productivity, unfortunately, has resulted in the proliferation of the perception that CDFG lacks within its ranks personnel capable of conducting rigorous investigations. Ultimately, CDFG and the fish and wildlife resources for which it is the steward, will pay a political price for that folly. I encourage CDFG's administrators to ensure that, "...the Department become[s] more highly respected in the scientific community" (Loft 1992). A major reorganization, which will elevate applied research to its proper level of importance in what was once the Nation's premier fish and wildlife conservation agency, clearly is in order. Perhaps the much-lauded comprehensive management system (CDFG 1993) will provide the mechanism by which such a change can be implemented.

LITERATURE CITED

Bleich, V. C. 1981. Review comments. Pages 567-568 *in* C. E. Conrad and W. C. Oechel, Tech. Coords., Proc. Symp. Dynamics and Management of Mediterranean-Type Ecosystems. USDA For. Serv., Gen Tech. Rep. PSW-58.

California Department of Fish and Game. 1993. A vision for the future. Calif. Dep. Fish and Game Admin. Rep. 93-1. Sacramento, Calif. 45 p.

Loft, E. R. 1992. *California Fish and Game*, California's longest continuously published journal. Calif. Fish and Game 78:174-176.

Soule, M. E. and B. A. Wilcox (eds.). 1980. Conservation biology. Sinauer Assoc., Sunderland, Mass. 385 p.

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